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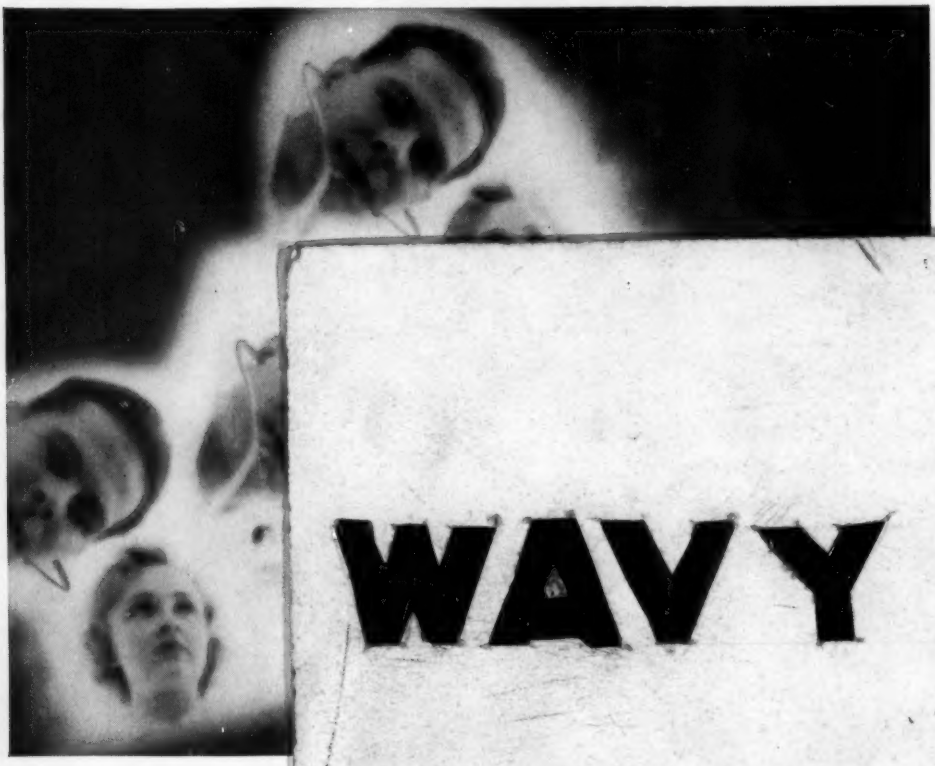

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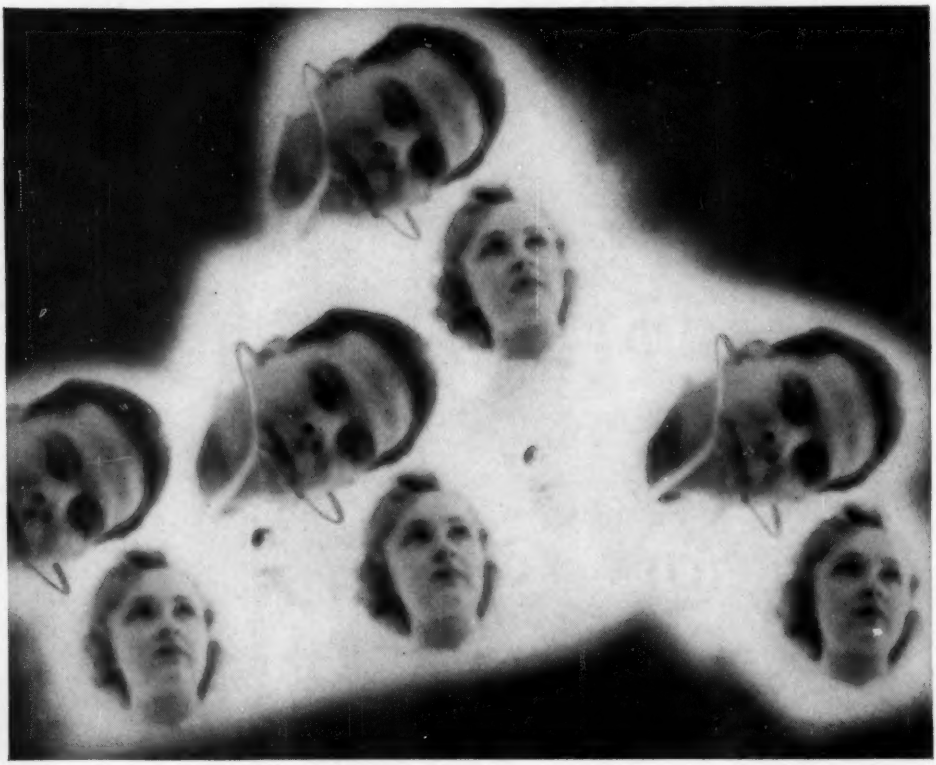

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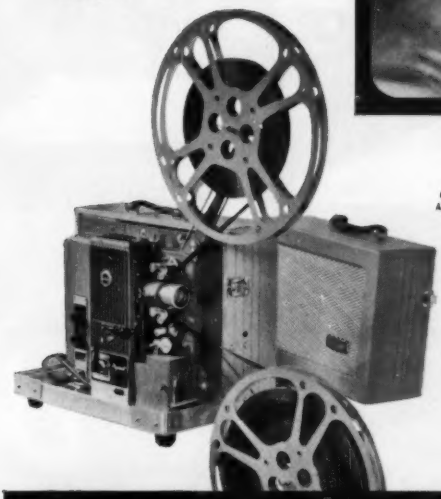

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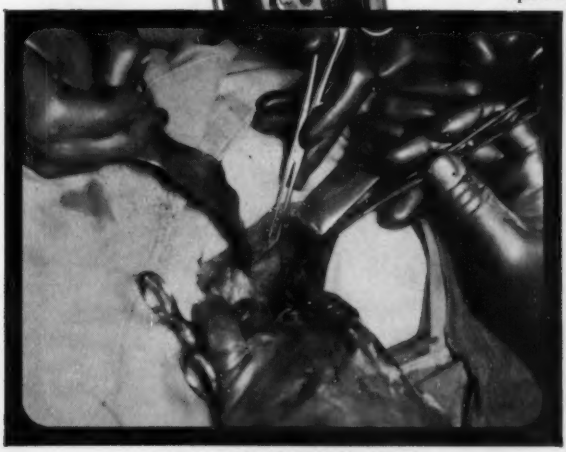

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SURGERY

Internal Carotid Artery Thrombosis

BROOKE ROBERTS, M.D.; GERALD W. PESKIN, M.D., and FRANCIS A. WOOD, M.D., Philadelphia

Practitioners of medicine have long recognized the clinical entity known as "stroke," or "cerebral vascular accident." For many years the cause of the neurologic manifestations has been evident, as either hemorrhage or thrombosis. Similarly, the syndrome of internal carotid artery thrombosis and certain of its sequelae have been recognized. However, it was not until 1937, when Egas Moniz [12] reported finding 4 cases of thrombosis among his 500 angiograms, that interest was stimulated in this condition and its recognition became more frequent. The increasing recognition of carotid artery thrombosis has paralleled the growth of cerebral arteriography and the establishment of this procedure as a safe and useful diagnostic tool. It is now appreciated that a considerable number of cerebral vascular accidents are the result of thrombotic occlusion of the carotid artery. In view of the potentialities of vascular surgery today, it is clear that physicians must become aware of the possibility of carotid artery thrombosis and stenosis in the differential diagnosis of patients with a "stroke." Only in this way can the correct diagnosis be established early enough to grant these patients the optimal chance for reestablishment of the circulation and for recovery.

Submitted for publication July 31, 1957.

From the Harrison Department of Surgical Research, University of Pennsylvania School of Medicine, and the Department of Surgery, Hospital of the University of Pennsylvania.

Assistant Professor of Surgery, University of Pennsylvania School of Medicine (Dr. Roberts). Fellow, American Cancer Society; Associate in Surgery, University of Pennsylvania School of Medicine (Dr. Peskin).

Incidence

Although the exact incidence of this lesion is not known, it has become apparent from the multiple reports appearing in the literature since 1942 that carotid artery thrombosis occurs in a much larger percentage of patients than was formerly appreciated. In that year, Hultquist [9] noted the presence of this difficulty in 69 cases from among 3500 routine autopsies. Among patients having cerebral disease the incidence is much higher. Webster, Gurdjian, and Martin [20] recently reported 70 cases among 803 patients undergoing cerebral angiography in a five-year period. The rapidity with which the incidence of this diagnosis has grown is exemplified by a number of recent reports. When Johnson and Walker [10] reviewed the literature in 1951, they could find only 107 clinical cases, including their own. Within several years, Poppen [14] added 25 cases observed at the Lahey Clinic; Thomson,[18] of England, wrote of 22 cases, and Boldrey and his associates [1] contributed 24 cases from the University of California. Additional cases are being reported with regularity, and undoubtedly the commoner use of arteriography has been one of the prime contributors to this trend. It is safe to predict that the lesion will be recognized even more frequently, for there are many patients having the condition who are not yet being subjected to arteriography. Carot-

id artery thrombosis is a condition which can be readily overlooked unless the examining physician has a "high index of suspicion." Within the past six months we have seen five patients with this difficulty at the Hospital of the University of Pennsylvania. Four of these were operated upon and constitute the basis of this report.

Etiology

The etiologic factors responsible for this condition appear to be varied and include thromboangiitis obliterans, trauma, and thrombosis of a cerebral aneurysm, but in the majority of these patients arteriosclerosis appears to be the responsible antecedent. Boldrey and associates [1] reported several cases in which the transverse process of the atlas impinged on the internal carotid artery with motion of the neck and clearly demonstrated the pressure exerted by the bone on the vessel when the patient's head was turned to the opposite side. Boldrey believed that in as many as 25% of cases carotid artery thrombosis owed its origin to this anomalous relationship. This has not been our experience in this limited series.

Arteriosclerotic change of the carotid vessel is most commonly observed in two areas, the region of the bifurcation of the common carotid artery and the carotid siphon. Why these segments should be particularly susceptible to degenerative changes and thrombosis is not entirely clear, but many investigators believe the phenomenon is related to physical factors of hemodynamics, primarily the eddy currents produced in the vessel at these points. Regions of bifurcation generally appear to be prone to arteriosclerosis and occlusion. Fortunately, the carotid bifurcation is more commonly involved than is the siphon, and occlusions usually begin at or just distal to the origin of the internal carotid artery, an area which is surgically readily accessible. From this point, the thrombosis commonly propagates along the course of the internal carotid artery until it reaches its first major branch, the ophthalmic. The thrombosis can extend beyond this point, but most frequently stops here, probably because of the inflow through collateral circulation. It is interesting to note that prior to actual occlusion by thrombosis the progressive arteriosclerotic changes narrow the lumen of the artery and thereby reduce the flow through it. This phenomenon accounts for the transient premonitory symptoms and signs experienced by many patients and permits prophylactic therapy at this time, with direct approach to the vessels. Needless to say, the collateral communications nourishing the brain are also vitally important in establishing the pattern of signs and symptoms.

Diagnosis

Thrombosis of the internal carotid artery is usually found in patients of middle age, being most frequently noted in the fifth decade. It is uncommonly present in the early or late years of life. It may, however, occur at any age, and we recently learned of a patient of less than 2 years of age who had spontaneous thrombosis of this vessel. The disease afflicts males predominantly, by a ratio of 4 to 1. The predilection for men and the occurrence in middle age are characteristics similar to those of other occlusive vascular processes.

The clinical picture of carotid artery thrombosis may follow one of several patterns. Many of the patients give a history of previous transient episodes of paresthesias, aphasia, and hemiparesis, often of gradual onset and rapid disappearance, which is sometimes incomplete. Days, weeks, or even months may pass before paralysis reaches its peak. Headaches, usually on the involved side, are common and generally precede the hemiparesis by a considerable period of time. Convulsions, both localized and generalized, have been reported, and a significant number of cases have been found among patients originally suspected of having a brain tumor. Although not a common symptom, loss of vision in one eye from ischemia with contralateral paralysis may occur and when present is almost pathog-

nomonic of this disease.[8] Associated changes of ischemia may be found in the eyegrounds. The majority of patients do not have permanent visual loss, but approximately 10% have transient visual disturbances and 5% have homonymous field defects because of involvement of the brain itself, rather than of the eye.[2] This slowly evolving pattern is often step-like in its progression, with occasional acute exacerbations of weakness, often in the hand or arm first, later spreading to the lower extremity.

In establishing the diagnosis of carotid artery thrombosis, one may employ several helpful maneuvers. By placing the examining finger on the intraoral lateral pharyngeal wall, the internal carotid artery can usually be palpated. If there is a pulse on one side and not the other, one should seriously entertain the diagnosis. It should be noted, however, that in some patients a pulse, though present, may not be palpable, and in others a pulse may be felt despite the presence of a block[5,15] if the occlusion is entirely intracranial. Measurement of the retinal artery pressures is also helpful in diagnosis.[17,19] If there is a block in the internal carotid artery proximal to the origin of the ophthalmic branch, the pressure within the retinal arteries of the eye on the affected side will be considerably lower than in the contralateral eye. A dynamometer and ophthalmoscope are employed for this determination (Fig. 1). We have found this examination to be extremely helpful.

Fig. 1.—Method of determination of relative pressures within the retinal arteries. The exertion of sufficient pressure to exceed the diastolic pressure in the vessels results in visible emptying of the vessels with each pulse, and when the systolic pressure is exceeded the arteries remain collapsed.

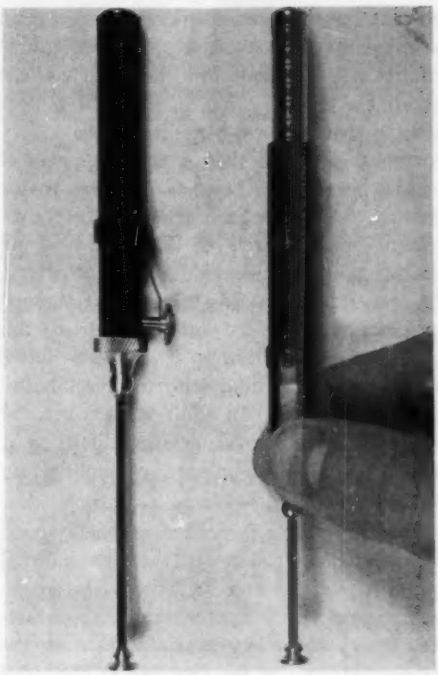


Fig. 2.—The dynamometer used in determining relative pressures in the retinal arteries.

The definitive diagnostic test is arteriography, in which a radiopaque dye is injected percutaneously into the common carotid artery. If the findings on palpation or the retinal artery pressure determination is suggestive of occlusion, arteriography should be carried out promptly. In general it is not difficult to interpret the arteriograms when there is thrombosis in the internal carotid artery. Chambers[3] has carefully reviewed the x-ray evidence of occlusion, pointing out the diagnostic features.

Anatomical Considerations

Pereira,[13] in reviewing the anatomy of the cerebral blood supply, appropriately pointed out the extreme variability of the vascular patterns. As stated previously, the variations in vessels undoubtedly account for the varied symptom complexes noted in the early phases of this disease. In the

so-called normal patient, the internal carotid artery pursues a relatively straight course in the neck without branching. Upon entering the carotid canal, in the petrous portion of the temporal bone, it follows a very tortuous, double-S-shaped route, giving off a few small branches and its first major branch, the ophthalmic artery, before continuing to the circle of Willis, where its extension forms the middle cerebral artery. At the circle of Willis it gives off the anterior cerebral artery and, opposite it, the posterior communicating artery. The latter vessel provides a link with the basilar and vertebral arteries. In addition, between the two anterior cerebral arteries there is a small vessel, the anterior communicating artery.

In many people there is a reasonably good cross circulation between the two internal carotid arteries, and in others no major connections exist. Fortunately, the ophthalmic artery has many anastomoses with the smaller arteries of the face and is therefore a vessel which may have considerable capacity for collateral flow with proximal occlusion of the internal carotid artery. Collateral blood supply may come not only through the ophthalmic but also through the anterior cerebral and posterior communicating arteries. From the surgical viewpoint, it is unfortunate that the internal carotid assumes such a tortuous path as it enters the bony skull, since it makes endarterectomy extremely difficult.

Therapy

Multiple therapeutic approaches to this problem have been attempted and, in general, have proved ineffective. Initially, such supportive treatment as abdominal binders, elastic stockings, and avoidance of hypotensive drugs were employed in an attempt to prevent depression of blood pressure and maintain collateral circulation. Ephedrine and atropine have been used to reduce carotid sinus depression of blood pressure. Anticoagulant agents, such as heparin and bishydroxycoumarin U. S. P. (Dicumarol), have been given, without success.[11] Such surgical measures as cervical sympathectomy, arterial stripping, and carotid-jugular anastomoses have given uniformly poor results.[13] Within the last few years, promising results have been achieved by endarterectomy, by excision of stenotic areas, with restoration of continuity, and by vascular grafting.[4,6,7,13,16] Caution, however, must be used in judging the results of therapy in this field, since it is well known that spontaneous improvement sometimes occurs. It is impossible to predict the degree of recovery that will occur in a given patient, and it is important also to recall that in many people one internal carotid artery can be ligated without apparent neurologic sequelae.

The degree of neurologic involvement depends upon the area of brain tissue to which the blood supply is insufficient. It is well known that nervous tissue is readily susceptible to injury and permanent damage from anoxia, and that the longer and severer the period of anoxia the more likely is irreparable damage to result. The recovery of neurologic deficit following cerebral anoxia is probably due, at least in part, to the return to a functional status of brain tissue previously rendered nonfunctional but nevertheless still viable. Presumably, this recovery occurs at the periphery of an area of actual necrosis where the collateral circulation, though inadequate to maintain function, is still able to preserve viability.

While ideal therapy for internal carotid thrombosis is the immediate restoration of flow through the diseased vessel, even delayed attempts at production of patency after thrombosis seem justified in the hope of returning to normal functional capacity the region of borderline anoxic change.

With the above thoughts in mind, we have operated upon four patients in an attempt to restore flow through a thrombosed internal carotid artery.

Report of Cases

CASE 1.—A 56-year-old white man was admitted to the neurology service of the Hospital of the University of Pennsylvania on Oct. 23, 1956.

Initial inquiry revealed that he had noted the gradual onset of weakness and numbness of the right arm and leg over the two-month period preceding admission. In addition, he had noted intermittent headaches, aphasia, dizziness, and weakness of the right side of his face for two months. About one month before admission he had an episode of blindness of his left eye, which lasted a few minutes and then cleared spontaneously and completely. Five days prior to admission he experienced the sudden onset of weakness and numbness of his right arm and incontinence of urine. Physical examination at the time of admission revealed cataracts; absence of the dorsalis pedis and posterior tibial pulses bilaterally; strong and equal carotid pulsations, with a murmur over the left carotid artery in the neck; right facial paralysis; right sixth nerve paralysis; a positive Babinski sign on the right; paralysis of the right hand, arm, shoulder, and scapular muscles, and weakness of the right leg. The admission diagnosis was cerebral vascular accident, and he was started on routine care and on anticoagulant therapy with heparin.

The admission laboratory studies were all within normal limits. Lumbar puncture was performed on Oct. 25, and revealed clear fluid under normal pressure. No cells were present on microscopic examination. An ophthalmologist reported myopia, Grade 1 arteriolar sclerosis, and normal visual fields.

With conservative treatment, the patient remained comfortable and made considerable progress. On Oct. 27 retinal artery pressures were measured. On the right the pressure was 90/40 dynamometer units, and on the left, 30/5-10. The diagnosis of carotid aneurysm was then more seriously entertained. Because of the poor general condition of the patient, much deliberation was carried out before a left carotid arteriogram was done, on Nov. 8. This test established the diagnosis of internal carotid artery thrombosis. Retrograde flow through the ophthalmic artery into the carotid siphon was noted. The proximal end of the block was thought to be at the bifurcation area. Surgical consultation was requested, and exploration was recommended in an attempt to relieve the carotid block.

The patient was taken to the operating room on Nov. 9, where, under general endotracheal anesthesia, the carotid bifurcation was exposed through a linear incision at the anterior border of the left sternocleidomastoid muscle. A thrombus was felt in the internal carotid artery and removed by suction after an arteriotomy. Moderate "backbleeding" was obtained. When this incision was closed, however, flow through the internal carotid was poor, and a second arteriotomy was made in the common carotid and an endarterectomy performed. This resulted in little additional improvement. Finally, using a freeze-dried arterial homograft, a shunt was established between the common carotid and the proximal internal carotid artery. Flow was excellent at the conclusion of this procedure. The patient tolerated the operation well. Heparin treatment was reinstituted immediately.

The patient's postoperative course was good. The next morning he could move his right leg, and his speech was improved. Retinal artery pressures were taken, and a measurement of 120/70 was recorded in each eye. An internal carotid pulse could easily be felt. Return of function continued. On Nov. 17 programs of physical medicine and speech therapy were begun.

At the present time the patient is able to walk without aid. Function of the right arm has improved to a point of usefulness, and his speech difficulty has cleared.

CASE 2.—A 45-year-old white man was admitted to the Hospital of the University of Pennsylvania on Oct. 5, 1956. About three weeks prior to admission he noted transient numbness of the left side of his face. One week later he became aware of paresthesia of the fingers of the left hand, with weakness of this hand and of the left leg. A sudden, frank paralysis of the left hand and arm was apparent on Oct. 3, and generalized headache and weakness of the left leg appeared on Oct. 4. In eliciting the patient's past history, it was apparent that he had been involved in an automobile accident about one month before, being thrown against the steering wheel and striking his abdomen. No head injury was noted at the time.

Positive physical findings on examination included a blood pressure of 170/100 in each arm; a nontransmitted, soft systolic aortic murmur; absence of the right femoral pulse; moderate hypertensive retinopathy; mental confusion; left central facial weakness; marked weakness of the left arm and slight weakness of the left leg with a positive Babinski sign on the left, and left homonymous hemianopsia. Carotid pulsations in the neck were equal on the two sides. Retinal artery pressures on the day of admission were 120/50 in the right eye and 140/75 in the left eye. The next morning they were 105/48 in the right eye and 145/85 in the left eye. Routine laboratory studies were not unusual.

On Oct. 6 a left carotid arteriogram was made, revealing occlusion of the internal carotid artery from its origin to the siphon, which filled via the ophthalmic artery. Shortly thereafter the weakness of the left side became more marked, and the patient was taken to the operating room, where the right side of the neck was explored under general anesthesia. The internal carotid artery was sclerotic and occluded with old clot. An attempt was made to perform a thromboendarterectomy,

but, despite removal of some clot, retrograde flow was not obtained. The patient withstood the procedure well. Postoperatively he was given heparin, but no neurologic improvement was attained by the time of discharge.

CASE 3.—A 57-year-old white man was admitted to the Hospital of the University of Pennsylvania on Oct. 31, 1956. For three years he had mild, intermittent headaches. Five days prior to admission, while at work, he noted the onset of generalized headache and face pain. While driving home that evening, he experienced two episodes of transient blindness. A few hours after his arrival at home he collapsed but did not lose consciousness. He became partially aphasic and somnolent. Three days before admission he became hemiparetic on the right, with progressively increasing weakness to the time of admission. His aphasia became complete.

Physical examination on arrival at the hospital revealed a blood pressure of 130/80. All pulses were present, but the left carotid pulse was weaker than the right. He was aphasic, with total right hemiplegia and right central facial paralysis. He was areflexic on the right except for the ankle jerk. A positive Babinski sign was present on the right. Sweating was absent over the left side of the face and body. Palpation of the carotid artery in the tonsillar fossa revealed a good pulse on the right and only a hard cord on the left.

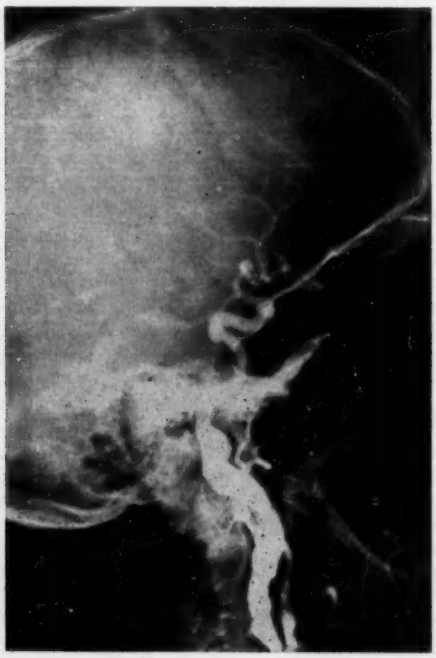
Laboratory studies were all within normal limits. Retinal artery pressure was 110/90 in the right eye and 60/40 in the left eye. A left carotid arteriogram was made on Nov. 2, revealing occlusion of the internal carotid artery with no retrograde flow (Fig. 3).

On Nov. 4 operation was performed through the left side of the neck, and a thrombosed internal carotid artery was cleaned by thromboendarterectomy until retrograde flow was obtained. Postoperatively a left carotid pulse was palpable in the pharynx, and retinal artery pressures were 130/80 in the right eye and 110/70 in the left eye. The patient was given heparin. No improvement in neurologic status was noted at the time of discharge. A postoperative left carotid arteriogram on Nov. 15 revealed a patent internal carotid artery to the siphon, but several major branches of the middle cerebral artery remained occluded (Fig. 4).

CASE 4.—A 53-year-old Negro man was admitted to the neurology service of the Hospital of the University of Pennsylvania on Aug. 29, 1956. A

Fig. 3 (Case 3).—Preoperative x-ray. Note the dye remaining at the origin of the internal carotid artery and the delayed filling of the carotid siphon via collaterals.

Fig. 4 (Case 3).—Postoperative x-ray, showing the open internal carotid artery but the remaining block of several major branches of the middle cerebral artery.



precise history was difficult to obtain, but the patient was apparently in good health until Aug. 2, 1956, when, while driving a truck, he noted "magnified and blurred vision." His truck struck a parked car. The patient did not become unconscious, nor did he sustain any head trauma. In an hour and a half his vision returned to normal. Soon thereafter his gait became unsteady, and he became unable to use his left arm in the usual manner. The next day he went to his place of employment as usual and there became aware of a "buckling" of the left knee. He began to bump into objects in front of him and to the sides, but mostly to the left side. A prefrontal and retrobulbar headache developed and persisted. Because of the decreased feeling in his left hand and foot and the left-sided weakness, he was hospitalized.

On examination at the time of admission the patient had a blood pressure of 120/80. Positive findings included absence of the right eardrum membrane with some purulent exudation in the external auditory canal, palpable peripheral pulses, early benign prostatic enlargement, and a thoracic scoliosis. The musculature on the left side of his body was hypertonic. He moved his left arm with difficulty and required help in moving his left leg. A left central facial weakness was present, as was a left homonymous hemianopsia. He had anesthesia to light touch on the left, with loss of sense of vibration and proprioception. His left biceps, triceps, knee, and ankle jerks were exaggerated. The right internal carotid pulsation was much less prominent than the left. Admission studies were within normal limits save for an electroencephalogram, which revealed abnormal activity of the right cerebral hemisphere. Retinal artery pressures were 95/40 in the right eye and 40/20 in the left eye. Accordingly, a right carotid arteriogram was made on Sept. 6, revealing thromboses of the internal carotid artery on this side (Fig. 5).

On Sept. 22, under hypothermic anesthesia (84 F), the right carotid artery was explored. The internal carotid was thrombosed, and through an arteriotomy incision much soft clot was removed but no significant "back-flow" was obtained. Postoperatively the patient was given heparin, but no neurologic improvement was noted by the time of discharge, on Oct. 5, 1956.

Fig. 5.—Preoperative arteriogram of Patient 4. Note the visualization only of the origin of the internal carotid artery.

Comment

These cases exemplify the typical history and physical findings in carotid artery thrombosis. In no instance was the patient's condition made worse by the operation. The technical difficulties in attempting to clean thrombus from the intracranial portion of the internal carotid artery can be formidable because of the tortuosity of the vessel in this area and the lack of exposure. In only two of our four patients were we able to reestablish flow through the vessel. At the present time we are attacking the problem by two approaches. Several spring-like reaming instruments have been tested in the internal carotid arteries of cadavers but have not proved satisfactory. We have used plastic tubing in short lengths as an endarterectomy instrument and have succeeded in attempts to pass the tube to the level of the carotid siphon in cadavers but not in patients with thrombosis. The ideal instrument should be flexible enough to traverse the course of the vessel, strong enough to strip the clot and any plaques, and have a central lumen to which suction could be applied. Our second approach has been concerned with the finding of a suitable enzymatic agent which will dissolve the thrombus if endarterectomy is not feasible.

We are currently planning to explore the use of plasmin (Actase).

Because the occluded vessels usually show considerable thickening of the walls and have small lumina, the possibility of recurrence of thrombosis following removal of the clot is real, and under certain conditions a graft may be used to advantage. At present, the use of grafts must be restricted to that portion of the vessel approachable through a neck incision, since suturing of a graft within the cranium is not technically feasible. We believe that thromboendarterectomy is the treatment of choice in most cases. Although there is some danger of displacing a portion of the thrombus into the distal cerebral circulation when performing an endarterectomy, the pressure present in cerebral vessels tends to resist embolization when the proximal end of the internal carotid artery is occluded.

Many authors have advocated some form of sympathetic block or sympathectomy in this condition. The operative removal of the upper and middle cervical ganglia is easily accomplished after exposure of the carotid artery bifurcation. However, we have not cut the sympathetic nerves because no convincing evidence has been set forth indicating that doing so materially increases the blood flow to the human brain, and it might have the disadvantage of shunting blood to the extracranial areas supplied by the external carotid artery. The production of a Horner syndrome would seem to be of little consequence if it could be shown that sympathectomy actually did enhance the chances for neurologic recovery, our primary objective.

Summary

Thrombosis and stenosis of the internal carotid artery is a far commoner occurrence than is generally realized. Its clinical manifestations are varied, and it should be considered in the differential diagnosis of cerebral vascular accidents and any progressive intracranial disease. The condition is usually found in men in late middle life and might be relieved surgically in a high proportion of cases if the diagnosis were made promptly. Diagnostic measures include palpation of the pulse, observation of arterial pressure in the retinal vessels, and carotid arteriography. Four cases and their surgical treatment are presented. In only one of these patients was the operation undertaken within 36 hours of the development of the occlusion, and in this patient alone was there significant neurologic improvement postoperatively.

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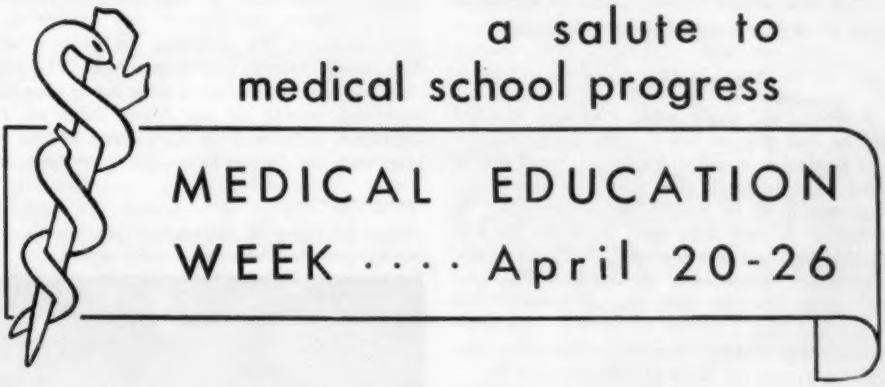

Primary Melanoma of the Esophagus

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Primary melanoma of the esophagus is exceeding rare. Since Baur's report [3] in 1905, reports of 17 cases have appeared in the literature. Six have had junctional changes in the overlying or juxtaposed epithelium, as set forth by Allen.[2] In the remaining 12 either the cases were not fully documented or the neoplasm had destroyed this change. Our recent experience focuses attention on the destruction of junctional change by an expanding lesion. Loring and Zeppa [8] formulated an excellent table of the previously reported cases.

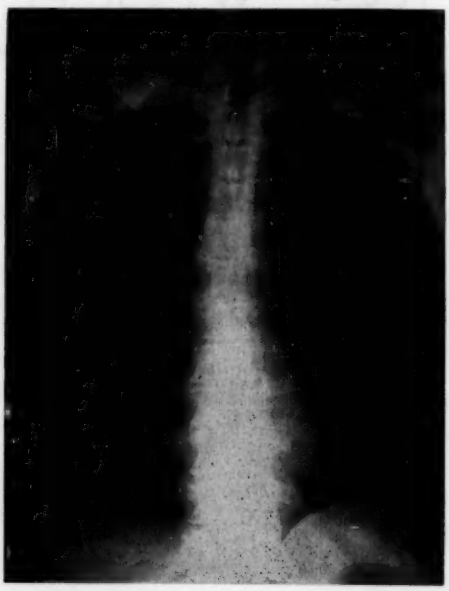
Report of a Case

A 64-year-old single white man was admitted for the first time on Jan. 7, 1956, complaining of four months' progressive dysphagia. Small sips of liquid could be taken very slowly by mouth, and there was a 40 lb. weight loss, accompanied by weakness. A dull ache over the right anterior costal margin had been present for one year. There was neither hematemesis nor melena. The past and family histories were noncontributory. The patient had been a laborer all his life. The blood pressure was 150/80. Physical examination was negative except for signs of recent weight loss.

Hemoglobin was 12.4 gm. per 100 cc. BUN, carbon dioxide-combining power, and serum sodium, potassium, and chlorides were within normal limits. The white blood cell count was 25,000, with 96% neutrophils, falling to 9900 after several days on penicillin. Urinalysis was within normal limits. The electrocardiogram showed nodal rhythm and an incomplete right bundle-branch block. Chest roentgenogram (Fig. 1) showed emphysema and an area of double density overlying the distal esophageal region posterior to the cardiac silhouette. Skeletal survey revealed no metastases. Barium swallow showed a dilatation of the proximal esophagus, with narrowing and irregularity of the mucosal pattern of the distal third and a large, well-circumscribed homogenous density in that area (Fig. 2). The stomach was within normal limits, with no retention of barium in three hours. There was minimal deformity of the duodenal bulb.

Esophagoscopy on Jan. 10, revealed a dilated upper esophagus and, 28 cm. from the upper gum margin, a necrotic polypoid tumor mass, beyond which examination was not possible. The microscopic report of the biopsy specimen was undifferentiated tumor in necrotic debris. The patient was prepared for surgery with fluids, blood, and antibiotics. On Jan. 18, through a midline incision, the abdomen was explored and, except for enlarged pigmented nodes about the celiac axis, was negative. After mobilizing the stomach and performing a pyloromyotomy, the abdomen was closed with through-and-through steel-wire sutures. The right chest was then opened, and a large tumor mass was visualized, arising in the lower third of the esophagus, infiltrating the right lower lobe of the lung and the pericardium, and extending into

Fig. 1.—Chest film (Bucky) showing double density overlying distal esophageal region.



Submitted for publication Aug. 30, 1957.

From the Thoracic Surgical Service, Veterans' Administration Hospital, Cleveland.

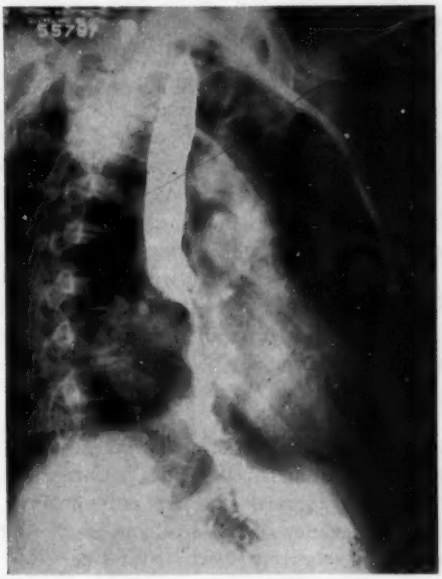


Fig. 2.—Barium swallow showing narrowing and irregularity in distal third of esophagus and posterior circumscribed density just above diaphragm.

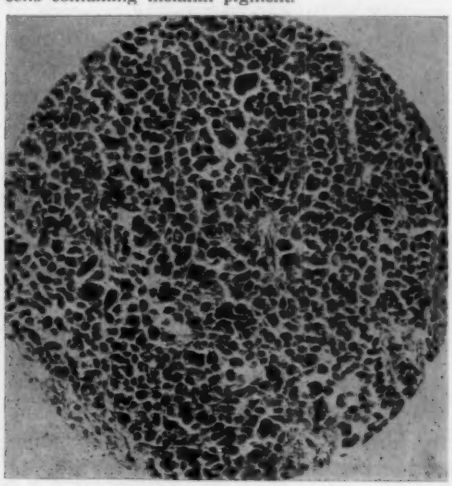
the left pleural cavity. Accordingly, a by-pass operation was performed, an esophagogastrostomy being done 1½ in. above palpable tumor, using a two-layer silk closure. The patient's immediate postoperative course was satisfactory. On the 10th postoperative day, he was eating well without regurgitation, and his temperature was normal. On this day an abdominal dehiscence, following removal of the sutures, was closed with wire, under spinal anesthesia. On the 12th postoperative day his temperature rose to 101 F; however, a chest film was negative. On the 14th postoperative day a fluctuant area under the right scapula was tapped and foul fluid obtained. The same day this empyema of the right chest was drained in closed fashion. On the 17th postoperative day, a Levin tube was introduced into the gastric pouch through an esophagoscope, and separation of the anastomosis was visualized. A feeding jejunostomy was performed at this time. Despite vigorous supportive therapy, the patient's course continued downhill, and he died on the 21st postoperative day. Autopsy permission was obtained.

Postmortem examination showed the esophageal tumor, a dehiscence of about one-half of the esophagogastric anastomosis, a recent gastric ulcer, a recent subcapsular hematoma of the spleen, and an infarct of an accessory spleen. The esophageal tumor measured 11×13×13 cm. and completely encased the distal one-third of the esophagus. The overlying pleura formed a pseudocapsule. The tumor was firm on section and showed a mottling of dark brown, black, gray, and yellow. The lumen of the esophagus was filled by polypoid, necrotic tumor, and only interrupted portions of the muscularis remained. No visceral or lymph node metastases were found. No other tumor or pigmented focus was found in the skin, subungual regions, anus, or meninges. The eyes were not examined.

Microscopic examination (Figs 3A and 3B) of this tumor revealed complete replacement of large

Fig. 3A.—Esophageal wall with tumor.

Fig. 3B.—Microscopic section showing tumor cells containing melanin pigment.



portions of the esophageal wall by closely packed ovoid to spindle-shaped cells, which tended to stream. The nuclei varied markedly in size, shape, and staining characteristics from ovoid to spindle-shaped, pyknotic to vesicular, hyperchromatic, and basophilic. There were prominent nucleoli. The cytoplasm was abundant and amphoteric, with long tesselated processes. Mitotic figures were numerous. Within the cytoplasm of many of the tumor cells there was a golden-brown pigment which did not stain with the ferric ferrocyanide (Prussian blue) reaction, was bleached with potassium permanganate and oxalic acid and was argentophilic. Multiple sections of the esophagus above and below the tumor did not show any junctional tumor foci. The tumor cells extended into the periesophageal fibroadipose tissue, but no tumor was found within the lymph nodes.

Comment

Since Baur's [3] report in 1905 of a case of primary melanoma of the esophagus with metastases found post mortem, several cases have been recorded. That such tumors are rare is attested to by the 18 cases reported.

In a review of 22,000 autopsies at Johns Hopkins University School of Medicine and Hospital, Burnett and St. John [7] found 25 cases of melanocarcinoma—but none of the esophagus, either primary or secondary. Allen and Spitz [2] reviewed 934 cases of melanoma and noted 63 melanomas (not of skin) in 52 patients. This series included one of the esophagus. These authors have set forth a currently acceptable criterion of primary melanocarcinoma—the presence of junctional nevus changes located at or near the periphery of the tumor. Robertson [10] feels that the rapidly growing tumor can destroy these changes. We agree with this.

There is controversy over the origin of the melanin pigment, as well as over the cells in which it resides. Origins from the rete mucosum of epithelium, mesothelial chromatophores, melanoblasts, and ectopic foci localized in the esophagus are some of the theories promulgated. The melanoblast (dendritic cell of Bloch) is a specific cellular entity located within the basal layer of the epidermis. It is dopa-positive (producing melanin via dopa-oxidase) and discharges its pigment into adjacent epidermal cells. In contradistinction, there is the theory of in situ production of pigment.

Becker, Klemperer, and Masson [4] are of the opinion that, rare as the tumor may be, the melanoblasts must be present in those esophagi in which melanomas arise. With Bielschowsky's silver method, melanin stains a deep black and is thus distinguished from other pigments, which remain unstained. Melanin gives a negative iron reaction, but in necrotic portions with hemorrhage the tumor cells may take up some iron-bearing pigments. Billingham [5,6] believes the dopa-positive cell stain is unequivocally specific.

Ackerman [1] observed that malignant melanoma is radioresistant, whereas basal-cell and squamous-cell tumors derived from ordinary epidermal cells are radiosensitive. The malignancy of these tumors is attested to by the relatively short survival period.

The tissue diagnosis was established by esophagoscopy and biopsy in 11 cases, by operation in 2 cases, and at autopsy in 6 cases. Therapy consisted of irradiation in 1 patient, symptomatic therapy in 6 patients, and surgical resection in 12 patients. Of the surgical group, four patients were alive at the time of each report, the postoperative period ranging from 6 weeks to 14 months.

Summary

A case of primary melanoma of the esophagus is presented, making a total of 19 cases in the literature.

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Systemic-Pulmonary Arterioarterial Fistula

Report of a Case

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Pulmonary arteriovenous fistula is no longer a rare lesion. One variant of this vascular derangement, however, has only twice been noted in the literature.[1,2]

The significance of pulmonary vascular fistulae connected with arteries of the chest wall lies both in the differences in clinical manifestations and in the problems which may be encountered in their surgical management.

Report of Case

A 24-year-old single Negro soldier was admitted to the Valley Forge Army Hospital on June 27, 1956. He had been originally seen two days before at the U. S. Army Hospital, Aberdeen, Md., where he complained of having had fever and chills since June 9. He had had a productive cough since that time, associated with severe chest pain and production of green-colored sputum. Three days after onset of his symptoms, he was confined to quarters and given penicillin for two days. He was subsequently x-rayed and continued on medication with penicillin, followed by chlortetracycline (Aureomycin), chloramphenicol (Chloromycetin), and sulfadiazine, without benefit. He was then transferred to Valley Forge Army Hospital with a diagnosis of pneumonia. At Aberdeen his white cell count had varied from 12,000 to 16,900 per cubic millimeter, with predominant polymorphonuclear leukocytes. His hemoglobin was found to vary between 9.75 and 11.25 gm. per 100 cc. Blood culture was negative after 96 hours, and his erythrocyte sedimentation rate was 51 mm. in one hour. On admission to Valley Forge Army Hospital, he still complained of severe painful cough, fever, and expectoration of light-green sputum.

The patient had worked for four years intermittently driving a truck for a fuel company, and, two years prior to his being drafted, he worked in a shipping and receiving department as a civilian at an Air Force base. He entered the Army in December, 1952, and had been at Aberdeen, Md.; Atlanta; in Korea; at Red River Arsenal, in Texas, and back to Aberdeen in 1955, where he remained until the time of admission.

He smoked about one pack of cigarettes daily and did not use alcohol or drugs.

The family history was noncontributory.

The patient stated that he had had chickenpox and frequent attacks of tonsillitis as a child. He was injured in 1945 in an automobile accident, sustaining fractures of his left thigh and arm. He believed he had had a "chancre" while in the service. He had been healthy generally in the past and stated that he had had only occasional headaches, aside from the incidents noted above. Except for these features, the systemic review was noncontributory.

Physical examination revealed a well-developed and well-nourished Negro man, obviously acutely ill. He coughed frequently, bringing up thick white to light-green sputum. Temperature 100 F; pulse 92 per minute; respirations 28 per minute; blood pressure 130/90 mm. Hg; height 5 ft. 10 in., (175 cm.); weight 147¼ lb. (66.8 kg.). On physical examination, the positive findings consisted of dullness over the anterior left chest, with rough bronchial sounds over the upper left lobe; these rhonchi cleared with cough. There were some small shotty cervical nodes. Otherwise, the examination was entirely negative.

Admission blood count revealed hemoglobin 10.3 gm. per 100 cc., with 3,040,000 red cells, markedly hypochromic, and 21,800 white cells, with the differential showing 73% neutrophils with 18% banded cells, 6% lymphocytes, and 3% monocytes. Hematocrit 34%. Corrected sedimentation rate was 32 mm. in one hour. Urinalysis was negative except for 3-5 white cells per high-power field.

The chest x-ray revealed a pneumonic consolidation on the left from the second to the fifth anterior rib (Figs. 1 and 2). The impression was that it involved the lingula of the left upper lobe.

During the first three weeks after admission, the patient exhibited daily spiking temperatures,

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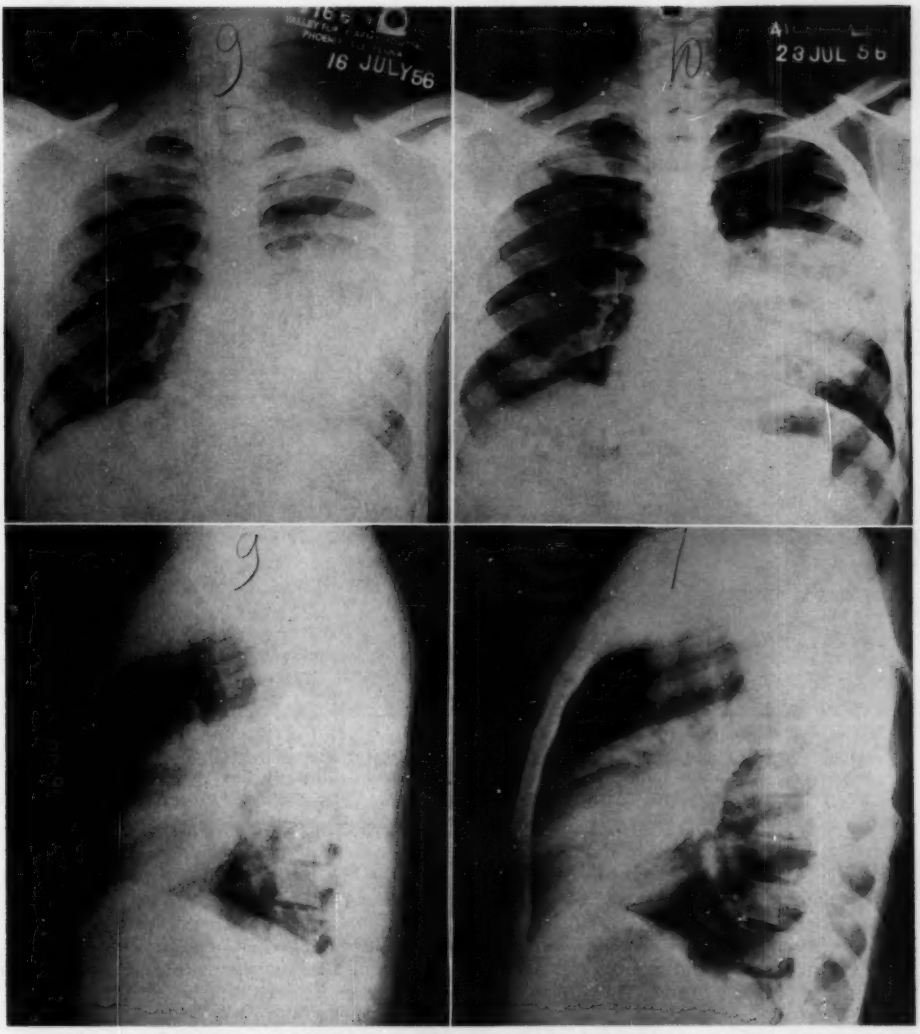


Fig. 1.—Roentgenograms taken early in the course of illness. Left: posteroanterior and left lateral 2-meter films; right: Bucky films. The infiltrative process seems to have been limited to the lingula of the left upper lobe.

rising as high as 104 F. During this period, numerous studies were carried out. Skin testing with purified protein derivative of tuberculin U. S. P. (first strength) was negative, and with the second strength, positive; histoplasmin, blastomycin, and coccidioidin gave negative results. Bacteriologic studies of sputum and gastric secretions were negative for tuberculosis. On July 2 a Gram stain of the sputum revealed Gram-positive cocci and yeast-like budding cells. Culture showed a predominance of α-Streptococcus. On numerous other reports, α- and β-streptococci, and occasionally Staphylococcus aureus, appeared, but always yeast-like organisms were noted on the smear. On July 12 these were thought to be Candida albicans. A fungus culture taken in July finally revealed, and was reported as, Blastomyces dermatitidis. This diagnosis was confirmed by mouse inoculation and by numerous repeat cultures throughout July and August. These included studies on aspirated material obtained at bronchoscopy. Complement-fixation tests were performed and early in July showed a 1:16 titer for blastomycosis. A colloidin agglutination test with histoplasmin was

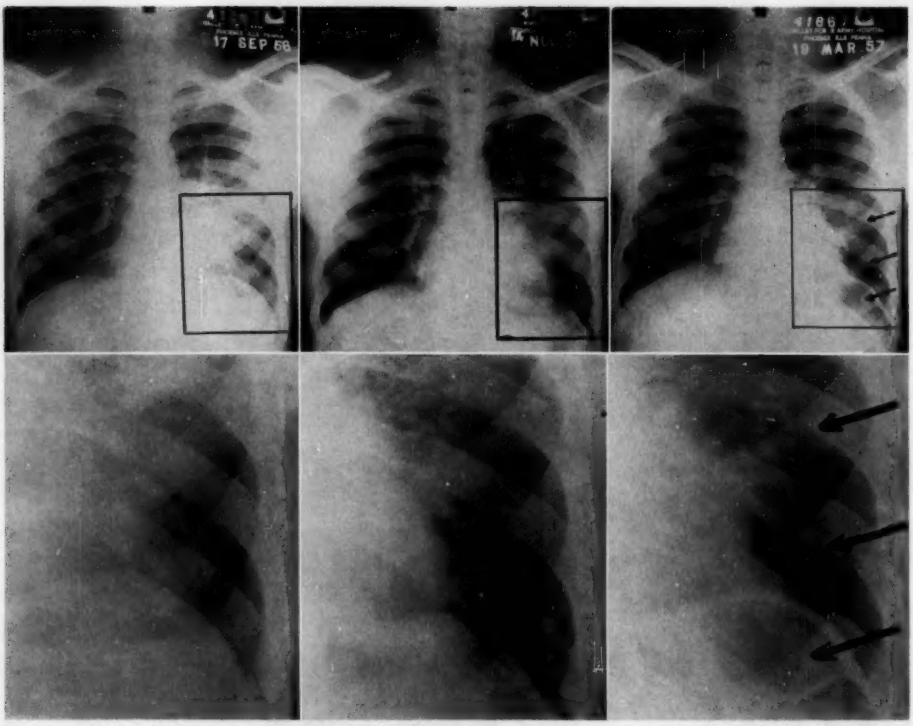


Fig. 2.—Serial roentgenograms showing slow clearing of the infiltration. In the November (center) and March (right) films, scalloping of the seventh, eighth, and ninth ribs is present. The areas in the insets are enlarged below to illustrate this change.

positive at 1:32; agglutinins for tularemia gave a negative reaction; the cold agglutination test revealed a 1:8 titer. Serum was negative for psittacosis-lymphogranuloma venereum, as well as Q-fever rickettsiae. There was progressive increase in blastomycin and histoplasmin titers, indicating activity throughout the months of July and August, with gradual reversal in October. By December, 1956, the complement-fixation tests were negative. The patient's blood counts gradually returned to within normal limits by the end of August. Other examinations included serologic and blood chemistry determinations; renal function tests and liver function tests were within normal limits except as noted below. The patient's treatment in the hospital consisted of a course of stilbamidine started on July 19. A note on July 23 indicates that a 2½×3 in. x-ray of the chest, taken Feb. 26, 1952, was negative. A similar film taken in November, 1954, showed an increase of pulmonary markings and some haziness overlying the left heart shadow but was considered within normal limits. By July 30 his clinical picture had improved considerably, but he was still bringing up a moderate amount of greenish sputum. The x-ray appearance of the lesion remained essentially unchanged. His temperature, however, had been below 100 F since July 27. On Aug. 4, after 16 days of stilbamidine (225 mg. daily), physical examination revealed persistent dullness, but no rales in the anterior left chest. At this time small shotty nodes were noted in the axilla and neck. A 2+ systolic murmur over the apex of the heart was first noted on this date. The x-rays showed slightly decreased extent of the infiltration. Administration of stilbamidine was continued daily until Aug. 16, at which time it was changed to alternate days. On Sept. 5 this therapy was discontinued because of mild elevation of sulfobromophthalein U. S. P. (Bromsulphalein) retention. The murmur, as noted above, was described as "sea-gull" type and was audible over the fourth and fifth intercostal spaces parasternally. A thrill at the apex was noted. In October, one observer detected a diastolic murmur in the same area as the previously noted systolic murmur. The infiltration of the left lung seemed to be slightly decreasing on x-ray and in December, 1956, was noticeably diminished. At this time the murmur had decreased in intensity and was described as a Grade 1 soft

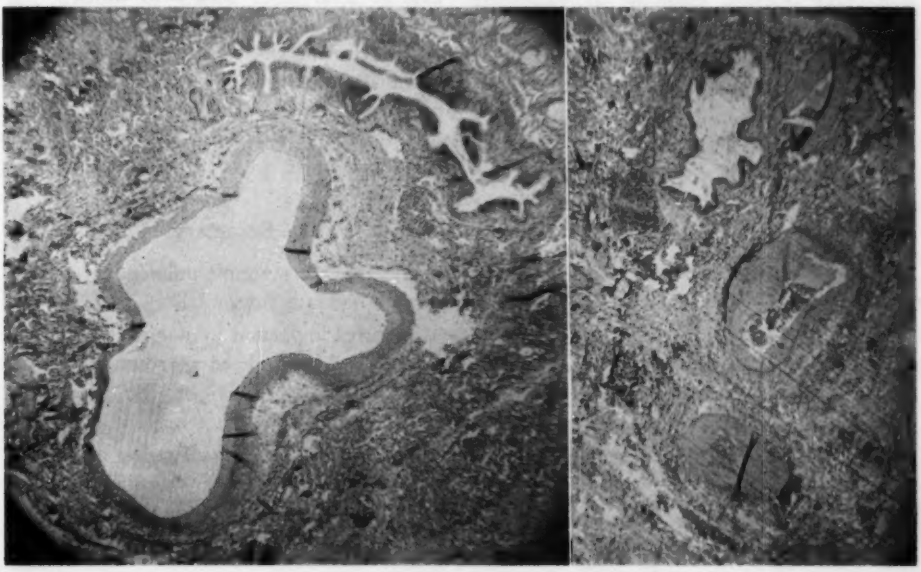
systolic murmur. On Nov. 27, a venous angiocardiogram was obtained, but failed to demonstrate pulmonary arteriovenous fistula. His course from this time until March, 1957, was one of continued clinical well-being, with gradual and very slow decrease of the infiltrative area on x-ray. On March 25 a second attempt at angiography was made, using a catheter in the pulmonary artery for the injection of the opaque material. This study was also unsuccessful. The murmur again was of Grade 2 to Grade 3 intensity and was thought to have a diastolic component. It was sharply localized to the apical area in the midclavicular line.

The patient was now considered for disposition by the medical-surgical board, and the consensus was that there was a pulmonary arteriovenous fistula which should be excised prior to returning the patient to duty. There was no cyanosis, no clubbing of the fingers, no polycythemia, and no peripheral arterial oxygen desaturation. Repeated EKG's were not remarkable.

The patient was transferred to the surgical service, and on April 12, 1957, a left thoracotomy was undertaken. The left chest was entered through the fifth interspace. Incision through the chest wall was associated with profuse bleeding, much more than is usually seen and resembling the situation encountered in patients with coarctation of the aorta. Upon entering the pleural cavity, the lung was found to be free except for an area of dense adhesions involving the lingula and the anterior chest wall. The lingula was shrunken, fibrotic, and atelectatic. In dissecting through the 6×8 cm. area of adhesions, profuse bleeding was encountered from numerous large arterial channels arising from the chest wall. Pulsatile bleeding of desaturated blood from the pulmonary side was also obvious. On closer inspection, several large tortuous vessels, identified as pulmonary arteries, were noted on the periphery of the lingula and were seen to have been separated from their counterparts on the chest wall, which were of systemic arterial origin. Inspection of the pleural surfaces revealed extremely large tortuous intercostal vessels, particularly those from the 6th through the 10th interspace. The mediastinal collaterals of the internal mammary and intercostal vessels were also dilated and tortuous. Hemostasis on the chest wall was difficult and tedious but was finally accomplished by the use of numerous simple ties and suture-ligatures. A routine lingulectomy was then performed. The remainder of the lung was not remarkable. It was estimated that the patient lost a total of 3500 cc. of blood during surgery, and this was replaced throughout the operation. The hilar pulmonary vessels and the aortic arch were not remarkable. Postoperatively, the patient had an uneventful course.

Examination of the specimen revealed dense and extensive fibrosis of the pulmonary tissue. The pulmonary artery branches were greatly dilated, and there were frequent clusters of dilated arterial

Fig. 3.—On the left is seen a markedly dilated, thin-walled pulmonary artery. On the right are seen three arterioles showing thickening of the wall, with nearly total obliteration of the lumen in one.



branches around the smaller bronchi. Microscopically, intimal thickening was seen in some of the larger vessels, although these generally had thin walls; but the arterioles showed widely distributed sclerotic changes, frequently resulting in nearly total obliteration of the lumen (Fig. 3). Bacteriologic studies of the specimen were negative.

The postoperative course was completely uneventful, and, after a month's convalescent leave, the patient was returned to duty in good condition, on May 24.

The clinical diagnosis of pulmonary arteriovenous fistula was made in this case on the basis of the sudden appearance of a murmur and thrill following a mycotic infection of the lung. This lesion was not associated with the common findings of cyanosis, clubbing of fingers, and polycythemia. Angiograms failed to show the anomalous vascular communication.

In retrospect, the reason for absence of the typical clinical findings and for failure of angiography is obvious. The usual pulmonary arteriovenous fistula is, as implied by the name, a communication between pulmonary arteries and pulmonary veins. Physiologically, this is a situation comparable to that of any right-to-left shunt. Desaturated blood mixes with arterial blood to a degree which may produce cyanosis and lead to the secondary manifestations of this, i. e., polycythemia, clubbing. Angiography routinely reveals the lesion because of increased circulation from the pulmonary artery via the fistula to the pulmonary veins.

In the case here presented, the fistula involved communication between systemic arteries (intercostals) and pulmonary arteries (lingular branches); the shunt could not be other than left to right, in view of the pressure gradient between systemic and pulmonary arteries. Thus, no mixing of desaturated blood with peripheral arterial blood was occurring. The situation here is physiologically identical with that of patent ductus arteriosus. This would explain not only the absence of cyanosis and clubbing but also the failure of venous angiography to demonstrate the lesion.

The only clues to the diagnosis were the murmur and thrill and the selective notching of ribs (Fig. 2). Had we noted the latter and realized the implications of these findings, an arteriogram might have been made and might well have proved the diagnosis preoperatively.

Surgically, the profuse bleeding during the incision of the chest wall was a strong indication that something atypical was present. The nature of the lesion became obvious when, in transecting the dense adhesion of lingula to chest wall, systemic arterial bleeding occurred from the parietal stump, and pulmonary arterial bleeding from the pulmonary stump, of the dilated vessels. In such a situation, it is imperative that the systemic-pulmonary shunt be interrupted before ligation of pulmonary veins is attempted. Failure to do this was the cause of death in the case reported by Flick [1] and nearly resulted in a fatality in the case reported by Burchell and Clagett.[2] In our own case, it was necessary to separate the lung tissue from the wall in order to carry out lingulectomy, and this was the major reason that the fistulous adhesions were divided initially. Availability of blood and the fact that the area of chest wall involved was not large were the saving factors. In retrospect, it appears that it might be advisable in such cases simply to transect pulmonary tissue between large clamps, leaving attached to the chest wall sufficient tissue to permit safer control of bleeding. This seems more reasonable than to attempt to ligate the innumerable arterial collaterals in the chest wall itself.

Summary

A case of systemic-pulmonary arterio-arterial fistula is presented.

Features important in diagnosis consist of presence of a localized murmur and thrill, absence of cyanosis or clubbing, and presence of selective notching of ribs.

The importance of realization of the existence of this type of vascular shunt in surgical management is indicated.

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Acute Pneumocholecystitis Associated with Perforation of Gallbladder and Pneumoperitoneum

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The phrase "acute pneumocholecystitis" has been used to designate an acute inflammatory condition of the gallbladder associated with gaseous distention of its lumen. The formation of gas in such instances is usually due to the presence of gas-forming organisms within the gallbladder and conditions favorable to their growth.

Among the many acute intra-abdominal conditions which produce clinical problems acute pneumocholecystitis is relatively rare. The rarity of this condition has been pointed out by most authors writing on the subject. In 1956 LaCour and O'Neil [2] were able to collect only 37 cases of acute pneumocholecystitis from the literature and added 1 of their own cases; since then no additional cases have been reported. Few cases, indeed, occur in the surgical experience of one person, and these are usually published as isolated case reports because of their rarity. Consequently, general surgical textbooks make scant reference to the condition, and any large series studied of necessity has to be taken from the surgical literature. No doubt, not all such cases are reported, but some idea of the infrequency of this condition could be obtained from the fact that throughout our entire surgical career we have observed only two such cases. We believe, therefore, that the disease is sufficiently uncommon to warrant a record of the following two cases.

This article contains an account of the clinical picture of acute pneumocholecystitis with perforation of the gallbladder and pneumoperitoneum. It is presented mainly in the hope that delays in recognition and treatment may be prevented.

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From the Adelphi Hospital, Brooklyn, and Mount Royal Hospital, Montreal.

Report of Cases

CASE 1.—A 58-year-old man was admitted to the hospital because of acute abdominal pain, nausea, and vomiting, of 48 hours' duration. He was known to have had diabetes for many years, but the disease was well controlled with diet and insulin. At the onset the pain was largely felt in the right upper abdomen, but it later spread to involve the entire abdomen, as well as the back. He has had no previous attacks of similar pain.

The physical findings on admission to the hospital were briefly as follows: The patient was well developed and somewhat obese; he appeared acutely ill and toxic. The tongue was dry and thinly coated. The heart and lungs were normal; blood pressure was 160/100 and the pulse 110 a minute. The abdomen was very tender and rigid throughout, but more particularly in the right subcostal area. There was also present a moderate degree of abdominal distention. No masses or organs could be felt, largely because of the tenderness and the resistance offered by the patient to palpation.

The urine was strongly concentrated and of a deep color; it showed a trace of albumin and a 4+ reaction for sugar and acetone, but no bile. The red blood cells numbered 4,550,000; the white blood cells, 24,000 per cubic millimeter, and the hemoglobin was 90%. The differential count showed a marked shift to the left. The blood sugar was 280 mg., blood urea 20 mg., and blood chlorides 500 mg., per 100 cc., and the serum amylase was raised to 200 units per 100 cc. (normal control, 100 units). A flat plate of the abdomen showed the presence of free air under the right leaf of the diaphragm (Fig. 1). The clinical impression was that the patient was suffering from a perforated viscus, probably a duodenal ulcer, and peritonitis.

After a brief preparation with parenteral administration of fluids, antibiotics, and insulin, the last to combat the hyperglycemia and acidosis,

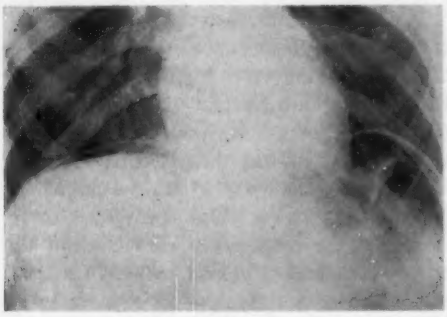


Fig. 1 (Case 1).—Flat plate of the abdomen, showing air under the right diaphragm.

surgery was undertaken. At operation, the peritoneal cavity was opened through an upper midrectus incision. The gallbladder was found enlarged and its wall thickened, edematous, and largely gangrenous. It presented a good-sized perforation in the fundus, which permitted a free escape of bile and stones into the peritoneal cavity. The cystic duct was moderately dilated, and its lumen was occluded by a large calculus. The adjoining viscera were covered with a fibrinopurulent exudate, and their serous surface was intensely hemorrhagic. There was no evidence of ulceration or perforation of either the stomach or the duodenum.

A cholecystectomy was done because of the large perforation and gangrenous condition of the gallbladder. Very little technical difficulty was encountered in removing the gallbladder. A cigarette drain was placed in Morison's pouch, and the abdominal wound was closed in layers.

The early postoperative course was very stormy and was marked by an elevation of temperature to 40 C (104 F), rapid pulse, and prostration. He was given parenteral fluids combined with large doses of antibiotics and insulin, the latter for the control of the diabetes. Continuous Wangensteen suction was instituted to relieve the abdominal distention. After several days of this treatment the patient began to rally and show evidence of improvement. The toxicity diminished, and the temperature began to recede to normal. He finally made a full recovery and was discharged from the hospital on the 18th postoperative day.

Histopathological examination of the removed specimen showed, in addition to a necrotizing cholecystitis and cholelithiasis, emphysema of the wall of the gallbladder. A culture of the gallbladder contents, when grown anaerobically, disclosed a growth of Clostridium perfringens.

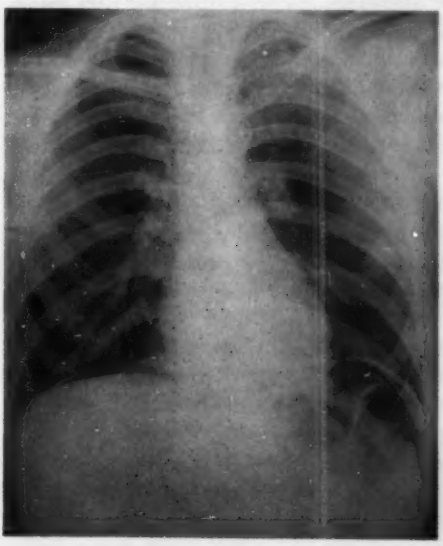
Case 2.—A 52-year-old man was admitted to the hospital with the chief complaint of acute abdominal pain, nausea, and vomiting of 30 hours' duration. The pain was described as sharp and colicky in character and largely confined to the right upper abdomen; it also radiated at times across the back and between the shoulder blades. He had suffered in the past from attacks of abdominal pain, which he ascribed to indigestion, but none was so severe as the present attack.

On admission to the hospital the patient appeared acutely ill and was moaning with pain. The skin was dry and of a bluish hue. The temperature was elevated to 40.5 C (104.9 F), and the pulse was rapid. The abdomen was distended, tense, and tender throughout. A tender, globular mass was felt in the right upper quadrant of the abdomen; it was taken to be an enlarged gallbladder. The edge of the liver was rounded and was felt 2 fingerbreadths below the right costal margin.

The red blood cells numbered 4,000,000; the white blood cells, 23,000 per cubic millimeter, and the hemoglobin was 85%. The differential count showed a preponderance of polymorphonuclear neutrophils. The blood sugar was 110 mg., blood urea 18 mg., and blood chlorides 475 mg., per 100 cc. The urine was essentially negative.

The clinical impression was that the patient had empyema of the gallbladder associated with a cystic-duct block. He was treated at first conservatively with parenteral fluids, antibiotics, and gastric intubation. The following day the abdominal pain became excruciating in character and the patient appeared to be in semishock. The abdomen was tender and rigid throughout, and the gallbladder could no longer be palpated. A flat plate of the abdomen taken at this time disclosed the presence of free air under the right diaphragm

Fig. 2 (Case 2).—Flat plate of the abdomen, showing a collection of air under the right leaf of the diaphragm.



(Fig. 2). It was believed that a ruptured viscus had developed, and immediate surgery was deemed advisable.

At operation, the abdominal cavity was found to contain a good deal of bile-stained, hemorrhagic fluid. The gallbladder was considerably enlarged, and was friable and gangrenous. There was a free perforation in its fundic portion, which permitted the escape of bile and stones into the peritoneal cavity. The cystic duct was occluded by one large stone.

No attempt was made to remove the gallbladder because the patient's grave condition did not permit it. Instead, a rubber tube was inserted into its lumen after removing a small piece of the wall for pathological examination. One cigarette drain was placed in Morison's pouch, and the abdominal wound was closed in layers.

Convalescence was marked by high fever, rapid pulse, cyanosis, and prostration. The patient was treated with parenteral fluids, large doses of antibiotics, and gastric drainage, to all of which he reacted very poorly. He finally lapsed into coma and died on the third postoperative day.

A culture of the gallbladder contents grown anaerobically showed Gram-positive colon bacilli. Histopathological examination of the biopsy specimen removed at operation showed acute gangrenous cholecystitis associated with mural emphysema.

Evaluation

Acute perforation of the gallbladder, of whatever source, always presents a surgical challenge, and a condition as treacherous as acute pneumocholecystitis and perforation is no exception. The gravity of the condition, as judged both subjectively and objectively, is directly related to the virulence of the offending organisms and the pathological changes produced in the gallbladder.

The ages of the patients in the present cases were 58 and 52 years, respectively, with an average of 55 years. This age group follows the usual pattern recorded in large statistical analyses dealing with cholecystitis and cholelithiasis. Both our patients were men. Although the present group of cases is far too small for statistical evaluation, it nevertheless points to the fact that the disease described is more prevalent in male patients. This is well in accord with the findings of most authors writing on the subject.

The clinical features of the well-established case of acute pneumocholecystitis are nowadays too well known to merit further repetition. There are certain points, however, particularly in the early diagnosis and in the prognosis of the disease, that are perhaps not so familiar, which we might be permitted to stress. Commonly, the early stages of the disease are characterized by acute abdominal pain and marked prostration. The clinical symptoms, however, are not specific of the disease complex and are unlikely to be recognized unless the possibility is in mind, or unless it is suggested by some fortuitous happening or investigation. The problem, therefore, is very often a difficult one, for the abdominal complaints may closely mimic to a nicety the symptoms of other acute intra-abdominal lesions, such as perforation of a peptic ulcer or acute pancreatitis. Maldiagnosis in these cases, however, has no repercussion on the patient, as surgical intervention via the same route is desirable in all cases.

In both our patients the onset of the disease was acute and sudden, and perforation of the gallbladder occurred early in the course of the disease. We attribute the early perforation of the gallbladder in such instances to the extensive necrotizing changes produced in its wall and to the rapid distention of the lumen with gas. There is no doubt that these two processes occurring together are most conducive to early perforation of the viscus. In the first case the gallbladder had already ruptured at the time the patient entered the hospital, whereas in the second case perforation occurred while the patient was in the hospital and was being prepared for surgery. A flat plate of the abdomen disclosed the presence of free air under the diaphragm in each instance; the latter finding was indicative of a ruptured intra-abdominal hollow viscus.

One of the patients had been suffering from diabetes mellitus for many years. Evidence has now accrued in the literature to indicate that this disease is not infrequently associated with acute pneumocholecystitis.

No explanation has been offered as yet to account for such an occurrence.

The only element common to all cases of acute pneumocholecystitis is the presence of gas within the gallbladder; when the organ ruptures, the gas escapes from the gallbladder, and it may be then found under the diaphragm. Once the diagnosis of acute pneumocholecystitis is justifiably made, the case is likely to be treated along the standard lines prescribed for these conditions, and further investigation is abandoned. On the other hand, no definite diagnosis may be made from the clinical investigation alone. It is possible that during the performance of radiological studies of the abdomen abnormalities of the gallbladder may be detected, thus giving an unexpected clue to the true nature of the disease present. Diagnosis of pneumocholecystitis is primarily based on x-ray findings. A flat x-ray plate of the abdomen reveals a large, globular, gas-filled gallbladder in the right upper quadrant. When a plate is taken with the patient in the erect position, the presence of a fluid level may be readily detected.

Most perforations of the gallbladder associated with acute pneumocholecystitis occur in the fundus. We [3] have previously shown that the same holds true with perforation of the gallbladder associated with all other forms of acute cholecystitis. It appears that the fundus is the most vulnerable portion of the organ because of its peculiar anatomy; it is the thinnest and least vascular segment of the gallbladder. Furthermore, the fundus, being the farthest away from the cystic duct, is the first to thin out, weaken, and perforate with increasing distention of its lumen.

Heifetz and Wyloge [1] have shown that when a normal or diseased gallbladder is inflated with air under controlled pressure, there occurs leakage of air, first, into the perimuscular layer near the cystic duct, and from there the air spreads perimuscularly until, with rupture, it escapes to the outside. Their findings suggest that mechanical factors are perhaps as important as bacteriologic in determining the clinical course of cases of acute pneumocholecystitis.

Two important disturbances have been suggested as etiological factors in the development of acute pneumocholecystitis and perforation of the gallbladder, and it is of considerable interest that these two conditions can occur simultaneously. One of these factors is mechanical blockage of the cystic duct, and the other is the presence of gas-forming organisms in the gallbladder at the time of blockage. In tracing events in the present series, it is noted that the cystic duct in each instance was occluded by a stone and gas-forming bacteria were recovered from each gallbladder. Of the various gas-producing organisms that are found in association with acute pneumocholecystitis, C. perfringens is perhaps the most commonly encountered. In the present series C. perfringens was found in one case and anaerobic, Gram-positive colon bacilli in the other.

There is clinical and experimental proof that the liver and bile radicles are a normal habitat for the Gram-positive anaerobic bacteria. It has also been shown that where the biliary tract or liver is injured, this system becomes vulnerable to the growth of anaerobic bacteria. It is the opinion of most investigators that this is the pathogenesis of acute pneumocholecystitis.

In a series of experiments which we have conducted in cats, we showed that the introduction of gas-forming bacteria into the cavity of a normal gallbladder resulted in no inflammatory reaction if the cystic duct was widely patent. When these experiments were repeated, however, with the cystic duct occluded by means of a ligature placed tightly around it, there followed a fulminating, gangrenous cholecystitis, together with emphysema and gaseous distention of the organ. In many instances the animals died shortly after the experiment with marked toxic reaction. Not infrequently, also, perforation of the gallbladder complicated the inflammatory picture. These experimental findings lend further support to the conten-

tion that the primary factors concerned in the development of acute pneumocholecystitis is complete blockage of the cystic duct and the presence of virulent, gas-forming organisms within the gallbladder. This block was total in our group of cases as far as could be ascertained.

The histopathological findings noted in acute pneumocholecystitis are quite unique and require very little comment. The main pathological feature, aside from the acute inflammatory process, is a striking emphysema of the wall of the gallbladder and distention of the lumen with gas; the emphysema may be local or diffuse. Both these changes were noted in our two cases. While no gas was found in the gallbladder in either of our patients at the time of operation, we are nevertheless convinced that it was present there prior to perforation of the viscus, since a flat plate of the abdomen disclosed the presence of free air under the diaphragm.

The importance of an early diagnosis cannot be sufficiently stressed because of its bearing on the prognosis. In the advanced stages of the disease, in spite of a correct diagnosis having been made and adequate treatment carried out, the extent of the inflammatory process usually present is commonly too advanced to be substantially altered. Death within a relatively short time after the onset of the disease or after operation is, unfortunately, a common enough occurrence. This was the case in our second patient, who died on the third day following operation, as contrasted with the first, who, in spite of a stormy convalescence, survived operation.

That surgical management of acute pneumocholecystitis is currently considered the treatment of choice is undisputed. Yet, in spite of this, operation is all too often delayed. Our present study and the investigation of others disclose the fact that the shorter the interval between the onset of symptoms and operation the better the prognosis. We [3] have proved this to be the case in all other forms of acute cholecystitis.

If the patient is seen early, and his general condition warrants it, an attempt at cholecystectomy should be made; this, we believe, is the treatment of choice. However, if the patient is seen late, when perforation has already occurred, it may become necessary to drain the gallbladder and not remove it. With adequate preparation of the patient, skillful anesthesia, precise surgery, and knowledgeable postoperative management, it is possible to operate even on the very ill patient. The hazard lies, rather, in the delayed cases, where technical difficulties surrounding the lesion and low resistance of the patient increase the risk of operation.

Summary

A review is presented of two cases of acute pneumocholecystitis associated with perforation of the gallbladder and pneumoperitoneum. In one case the offending organism was C. perfringens, and in the other an anaerobic, Gram-positive, colon bacillus.

Acute pneumocholecystitis and perforation of the gallbladder is a very rare occurrence. References to such an event are very scant in the literature.

The important factors concerned in the pathogenesis of this disease are complete blockage of the cystic duct and the presence of gas-forming bacteria in the gallbladder at the time of obstruction.

Some of the problems associated with the diagnosis, prognosis, and management of these cases are generally discussed.

1221 Albemarle Rd. (Dr. Jacob Rabinovitch).

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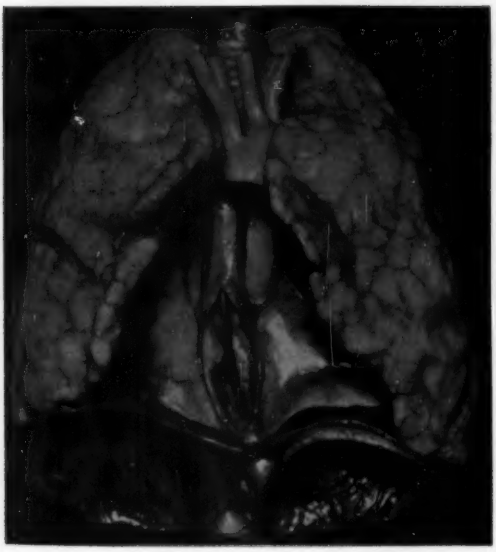


Esophageal lavage

Gastric lavage

Duodenal drainage

Colonic irrigation

Esophageal Lavage.—This manikin illustrates a No. 18 Levin tube situated just distal to an infiltrative squamous-cell carcinoma preparatory to irrigation.

Stomach Lavage.—A No. 18 Levin tube in position near an ulcer of undetermined etiology of the lesser curvature of the stomach.

Duodenal Drainage.—By means of a double-lumen Diamond tube exfoliated malignant cells may be recovered from carcinomas of the pancreas, common bile duct or gallbladder.

Colonic Irrigation.—Malignant cells can be recovered from carcinomas of the cecum and splenic flexure by irrigation through a No. 12 Ewald tube inserted to the rectosigmoid.

Illustrated Article

Gastrointestinal Cancer

Definitive Diagnosis by Exfoliative Cytology

HOWARD F. RASKIN, M.D.; JOSEPH B. KIRSNER, M.D.; WALTER L. PALMER, M.D.; SYLVIA PLETICKA, B.S., and WILLARD A. YAREMA, A.B., Chicago

Introduction

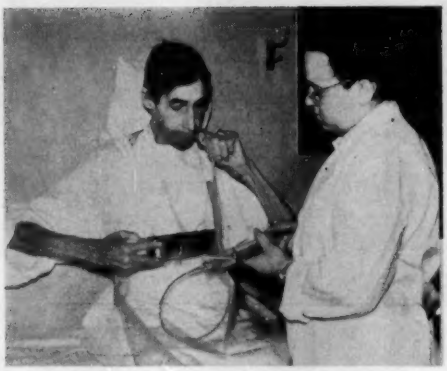
In recent years exfoliative cytology has become increasingly useful as a method of diagnosing cancer of the gastrointestinal tract. The cytologic procedures, as illustrated on the following pages, demonstrate the relative simplicity of the techniques. The methods of obtaining malignant cells from the esophagus, stomach, duodenum, and colon are satisfactorily performed by trained cytotechnicians. The presence of a physician is required for the occasional difficult intubation and for final interpretation of slides. It is most advisable for the person who actually performs the test to read the slides in order to evaluate the material best. Certain fundamentals of technique should be adhered to strictly. For instance, the least possible delay between aspiration and fixation of the material is constantly stressed in order to achieve good cellular preservation. A measure of skill is required in manipulating esophageal and gastric tubes when obstruction, gastroenterostomy, subtotal resection, or other anatomical abnormalities are encountered; the quality and quantity of the cellular yield are dependent upon the thoroughness of the lavage.

From the Department of Medicine, University of Chicago, The School of Medicine.

Shown as a scientific exhibit of the Section on Gastroenterology and Proctology at the 106th Annual Meeting of the American Medical Association, New York, June 3-7, 1957.

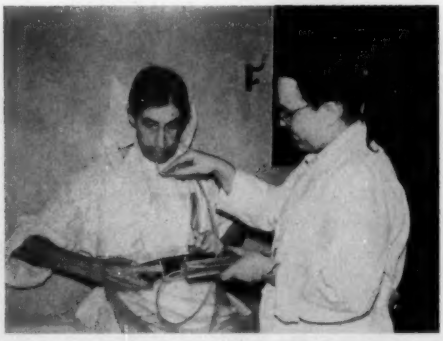
This project was supported by a field investigation grant from the National Cancer Institute, National Institutes of Health, U. S. Public Service, and by the Stewart Fund to the University of Chicago.

Esophageal Lavage



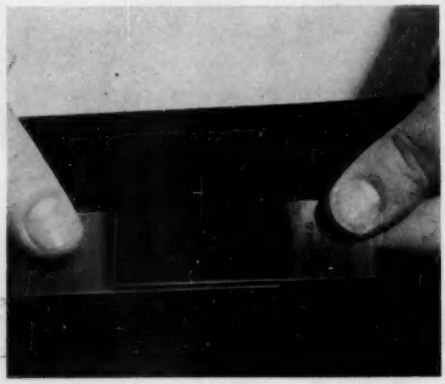
1. Patient is fasted overnight. A #18 F. rubber Levin tube is passed through the mouth to the 45 cm. mark.

2. An attempt is always made to pass the tube beyond an esophageal obstruction and enter the cardia. One hundred cubic centimeters of isotonic saline solution is swallowed and gently aspirated at the cardia.

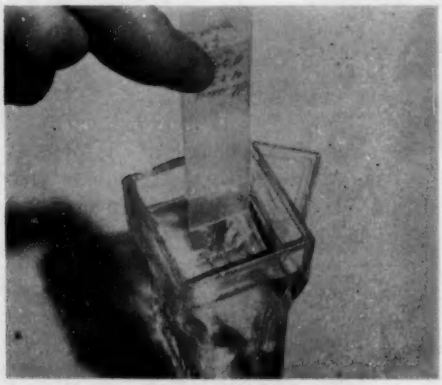


3. The tube is then withdrawn in 5 cm. segments. At each level a 20-40 cc. saline lavage is performed.

4. The aspirate is centrifuged at 5000 rpm for two minutes.

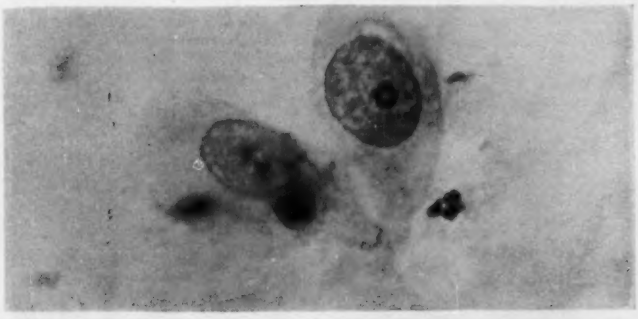


5. Cellular material is smeared on frosted slides.

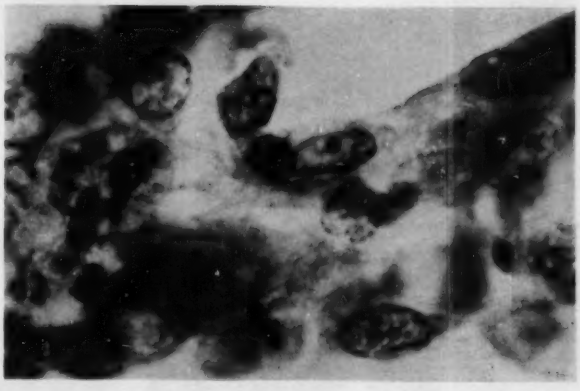


6. The two slides are placed back to back in an ether-alcohol mixture and then stained by the Papanicolaou method.

7. Normal esophageal squamous cells: oval, centrally located nuclei with a normal nuclear-cytoplasmic ratio.



8. Well-differentiated squamous-cell carcinoma, revealing enlarged nuclei, prominent nucleoli, and chromatin clumping.



9. Undifferentiated squamous-cell carcinoma with heavy chromatin clumping and irregular nuclear borders.

ESOPHAGEAL CYTOLOGY RESULTS

TOTAL CASES - 121

CLINICALLY BENIGN	68	CLINICALLY MALIGNANT	53
CYTOLOGY NEGATIVE	67	CYTOLOGY POSITIVE	50
CYTOLOGY FALSE POSITIVE	1	CYTOLOGY FALSE NEGATIVE	3

10. A cytologic false-positive report denotes a misinterpretation of benign cells as malignant. A cytologic false-negative result indicates a failure to find or to recognize tumor cells when malignancy is present.

Gastric Lavage

1. After an overnight fast a #18 F. Levin tube is passed orally to the antrum and the gastric residuum is aspirated. The stomach is then barbotaged vigorously for three minutes, using 300 cc. of saline solution, which is saved for cytologic studies.

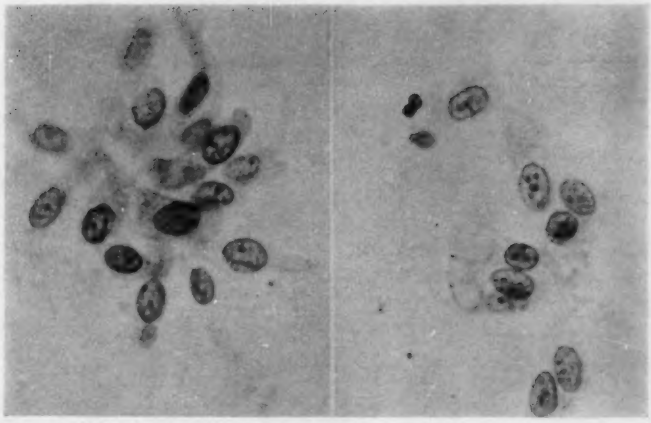
2. Five hundred cubic centimeters of sodium acetate buffer solution is then instilled.

3. The patient is placed on his right side: The position is rotated 90 degrees every two minutes.

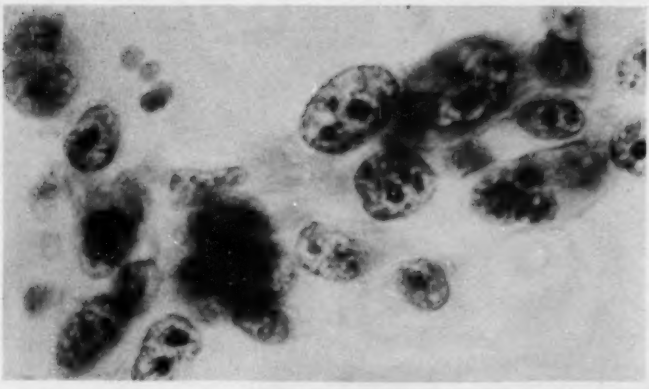
4. The patient is prone for two minutes.

5. The patient is on his back two minutes; stomach massaged.

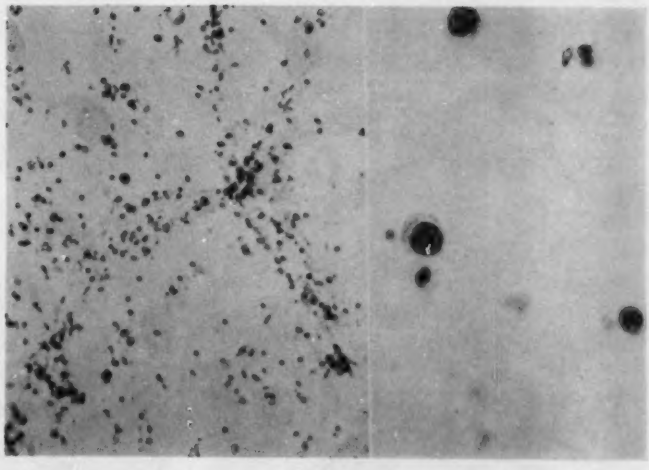
6. With the patient in the left lateral decubitus, the fluid is removed.



7. Normal gastric columnar epithelial cells originating from the gastric fundus (left) and the gastric antrum (right).



8. Malignant cells from an infiltrating carcinoma of the lesser curvature. Dense nuclear chromatin clumping is the outstanding feature of these cells.



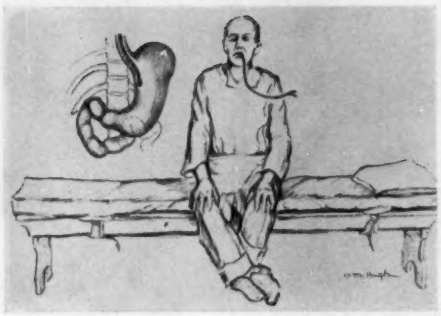
9. Two gastric lymphoma cells (lymphoblasts), as seen under low-power magnification (×100 left) and higher power (×450 right).

GASTRIC CYTOLOGY RESULTS

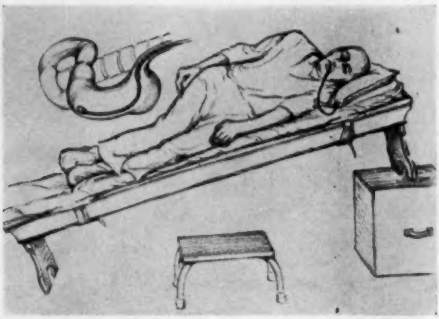
TOTAL CASES - 501

CLINICALLY MALIGNANT	98	CLINICALLY BENIGN	403
CYTOLOGY POSITIVE	93	CYTOLOGY NEGATIVE	400
CYTOLOGY FALSE NEGATIVE	5	CYTOLOGY FALSE POSITIVE	3

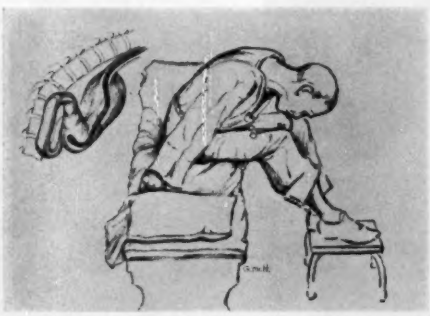
Duodenal Drainage



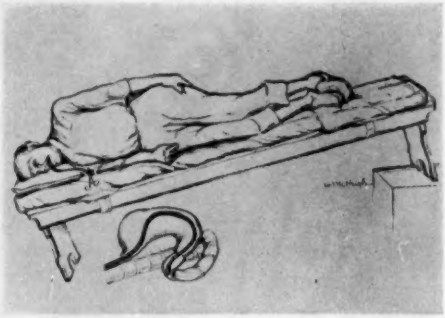
1. Method of rapid intubation: A double-lumen gastroduodenal tube (Diamond tube) is passed to the 45 cm. mark.



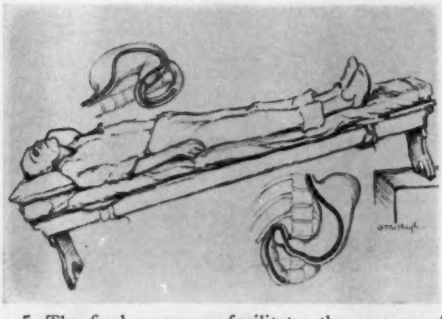
2. With the patient lying on the left side on an elevated cot, the tube is swallowed an additional 15 cm. so as to lie along the greater curvature.



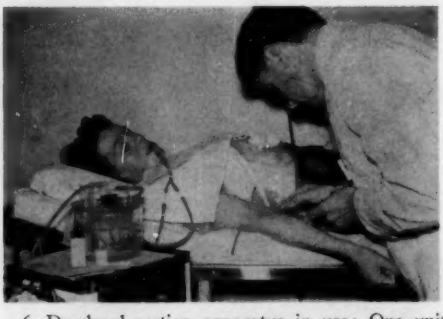
3. The patient bends forward and takes several deep breaths; the tip of the tube slips into the antrum as the anterior wall of the stomach falls forward.



4. The next step consists of having the patient on his right side, head down for five minutes, during which time an additional 15 cm. of tubing is passed.

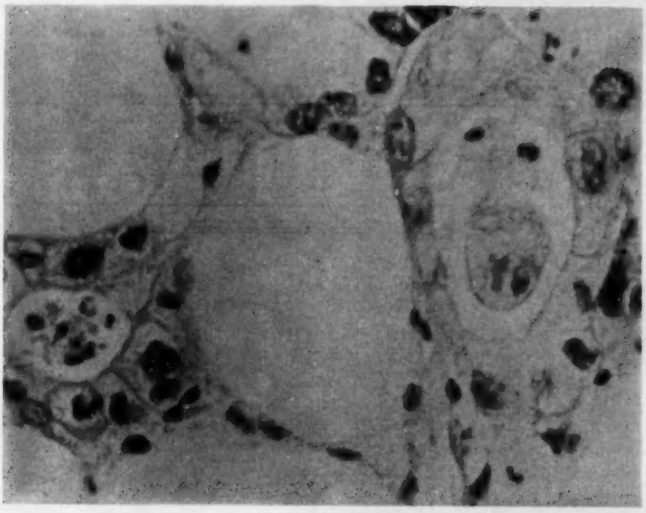


5. The final maneuver facilitates the passage of the tube into the third portion of the duodenum.

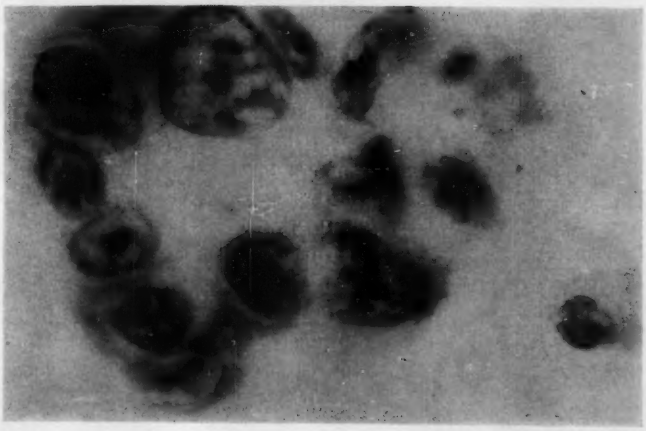


6. Duodenal-suction apparatus in use: One unit of secretin per kilogram of body weight is injected intravenously.

7. Well-differentiated adenocarcinoma cells obtained by a duodenal drainage. Tumor originated in the body of the pancreas and did not involve the duodenum.



8. Hematoxylin and eosin stain of biopsy section of the tumor. Note the morphologic similarities between the duct-forming cells and the cells of the preceding photomicrograph.



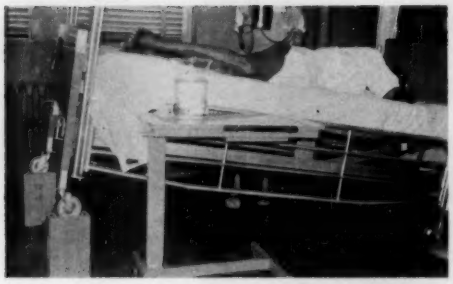
9. Highly anaplastic carcinoma cells, which exfoliated from a carcinoma of the gallbladder.

DUODENAL CYTOLOGY RESULTS

TOTAL CASES - 204

CLINICALLY BENIGN	159	CLINICALLY MALIGNANT	45
CYTOLOGY NEGATIVE	158	CYTOLOGY POSITIVE	30
CYTOLOGY FALSE POSITIVE	1	CYTOLOGY FALSE NEGATIVE	15

Colonic Irrigation



1. Colon-wash procedure: The patient is given a phosphate cathartic the night before the examination. Multiple isotonic saline enemas are given. Many patients can tolerate 3000-cc. enemas if the foot of the bed is elevated. Before expelling the solution, the patient rotates to his right side in order to irrigate the ascending colon.

2. A proctoscope is passed 20 cm., and an Ewald tube is inserted through the proctoscope, which is then removed.

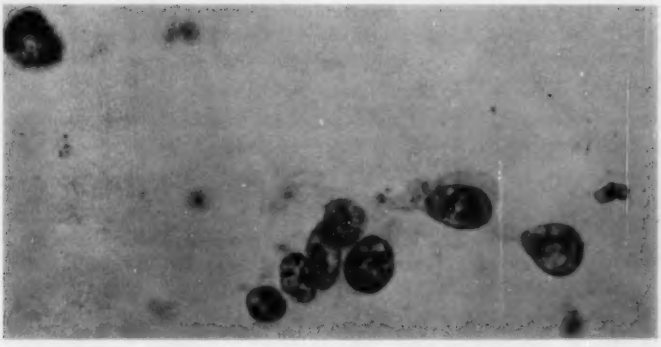
3. The first diagnostic enema consists of 700-800 cc. of isotonic saline, which gravitates to the transverse-descending colon junction.

4. The patient lies on his right side to enhance the flow of fluid to the hepatic flexure.

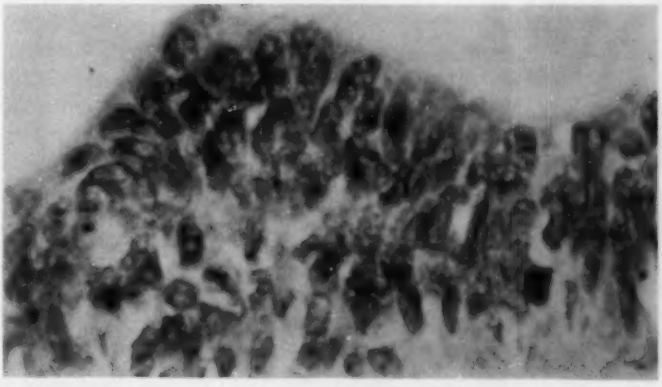
5. The patient rotates to his back, and the abdomen is massaged. Fluid is often balloted in the cecum.

6. Fluid is collected through a strainer into a beaker and then poured into centrifuge tubes. A second diagnostic enema is repeated.

7. Benign colonic columnar cells.



8. A cluster of adenocarcinoma cells obtained from a splenic-flexure malignancy.



9. Histologic section, stained with hematoxylin and eosin, of the splenic-flexure tumor from which the malignant cells in the preceding photomicrograph were obtained.

COLON CYTOLOGY RESULTS

TOTAL CASES - 122

CLINICALLY BENIGN	**97**	**CLINICALLY MALIGNANT**	**25**
CYTOLOGY NEGATIVE	**97**	**CYTOLOGY POSITIVE**	**23**
CYTOLOGY FALSE POSITIVE	**0**	**CYTOLOGY FALSE NEGATIVE**	**2**

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Pitfalls of Translumbar Aortography and Peripheral Arteriography

JOHN R. DERRICK, M.D.; WILLIAM D. LOGAN, M.D., and JOHN M. HOWARD, M.D., Atlanta

Recent advances in the field of vascular surgery offer new hope to patients with organic disease or trauma of the arterial system. It has therefore become increasingly important to evaluate accurately the patients with arterial disease in order that those with lesions amenable to surgical correction may be afforded the opportunity.

The patient with early occlusive disease may complain of pain in the leg, thigh, or lower back after exercise. As the occlusion progresses, the pain may occur after minimum exercise, later occurring even at rest. Gangrene is the final stage of progression. Strict evaluation of patients with arteriosclerosis is especially necessary, for the natural course of the disease is variable, many of the factors determining the prognosis being unknown. The clinical evaluation of each peripheral pulse, the presence or absence of trophic changes in the extremity, and the symptomatology often enable one to select candidates for arteriography. Although the clinical findings point to a definite occlusion, arteriography is still essential to permit the planning of the operative procedure. The arteriogram delineates the point of occlusion, the length of occlusion, and the status of the essential outflow tract beyond the point of occlusion. Furthermore, it delineates the more important collaterals which should be preserved during operation.

It is essential that the knowledge gained in subjecting a patient to translumbar aortography warrants the slight risk involved in the procedure. In the last 50 aortographic studies performed at Grady Memorial Hospital, a standarized technique has been employed to minimize technical errors. No complications have resulted. The need for delineation of the renal arteries or the aorta and its branches to the lower extremities constituted the indications for aortography. In 27 patients positive diagnoses were gained; in 23 significant information was gained by exclusion. In 8 of the 27 patients the knowledge gained was confirmatory of clinical impressions; yet the study was helpful because aortography defined the anatomical delineation of the disease.

The fear of arteriography was originally based upon the fear of puncturing the aorta or femoral artery, and, secondly, upon fear of the ill effects of the radiopaque dye injected. A review of the reported complications associated with arteriography and aortography indicates that most fatalities have resulted from technical errors or poor clinical judgment. With proper selection of patients and strict adherence to the basic principles of technique, the procedure carries a minimal risk to the patient.

Pharmacology of Contrast Media—Sensitivity Reactions

The iodine concentration of the contrast media which are commercially available for use in arteriography is 66% for acetrizoate (Urokon), 50% for iodopyracet (Diodrast), and 60% for diatrizoate (Hypaque). Thomson and associates [18] demonstrated that the iodine content determined the radiopacity of the various media. They were unable to determine whether the concentration of iodine in the medium also determined its toxicity.

Submitted for publication July 26, 1957.

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Shaw [15] demonstrated that patients receiving acetrizoate or iodopyracet for femoral arteriography developed a distal vasoconstriction which lasted for 2 to 13 minutes. When the dye was used in more dilute solution, vasodilation created a flush reaction distal to the point of injection. The study suggested that for patients who have evidence of peripheral arterial insufficiency a relatively dilute solution (35%) might be preferable. The irritability of these solutions may be due to their high concentration, a 70% solution having an osmotic effect approximately seven times that of plasma.[11]

Pendergrass and co-workers [12,13] surveyed the fatalities resulting from the administration of the organic iodine compounds which were used in urography. In 4,493,650 reported examinations, 57 deaths resulted, representing an incidence of 0.0013%. This study indicates the approximate incidence of sensitivity to the solution, for in these instances the injections were given very slowly and the amount of dye administered was small in comparison with the amount used in arteriography.

Renal Complications

In analyzing nine reported deaths [4] associated with translumbar aortography, two patients were found to have had a severe hemorrhagic diathesis, and four patients had unilateral or bilateral renal hypoplasia, so that the mass of functioning renal tissue was subnormal prior to injury. The combination of a high concentration of the drug and a resultant arterial spasm may partially explain these fatalities.[4] Furthermore, one of the patients had received three injections into the aorta within a relatively short period of time.

In testing the toxic effects of inorganic iodine compounds on the kidney of rabbits, Idbohrn and Berg [8] observed that a concentration of 17.5% produced injury to the kidney with exudation and degeneration, which was most marked in the tubules. If renal angiography was repeated after short intervals, damage to the kidneys was produced by a quantity of medium too small to have originally caused detectable injury, suggesting that the noxious effect of the dye on the renal tissue was cumulative. Repeated exposures to the dye at short intervals appeared to be fraught with an increasing danger. Alwall and associates [1] reported eight patients with severe renal damage who recovered; five had received repeated injections or single injections in excess of 50 ml. Burns [3] cited Hinman, who reported seven instances of renal damage after translumbar aortography; three of the patients sustained unilateral injury, while four developed oliguria or anuria lasting from 10 to 11 days.

Intestinal Complications

Four deaths have been reported [6,17,19,20] in which 80% sodium iodide was injected into the superior mesenteric artery. According to Melick,[9] most of the fatalities that have been recorded as resulting from injection into the superior mesenteric artery can be ascribed to the use and necrotizing effects of sodium iodide. He injected massive doses of 70% sodium acetrizoate directly into the superior mesenteric artery of dogs and found that it did not result in death or in intestinal necrosis. Wagner [20] reported a 41-year-old hypertensive woman who received a translumbar injection of 10 ml. of 80% sodium iodide, all of which went into the superior mesenteric artery. After five hours the patient went into shock, became comatose, and died three days later. The cause of death was considered to be mesenteric thrombosis or intestinal necrosis, although autopsy was not obtained.

Paraplegia Associated with Aortography

In six instances of paraplegia resulting from translumbar aortography, the paralysis evidently resulted from thrombosis of the anterior spinal artery. Baurys [2] suggested that by threading a catheter up the aorta or by taking preliminary films after only a small quantity of dye has been injected, one might predict and avoid injection of a high

concentration of the dye into the anterior spinal artery.

Local Complications Associated with Puncture of Aorta and Smaller Arteries

With reasonable care, the dangers inherent in puncturing the aorta or femoral artery are minimal. Dos Santos [5] reviewed 1500 cases of peripheral arterial puncture and found one instance of persistent bleeding as the only complication. Saltz and associates [14] reported two cases of pheochromocytomas in which death occurred due to retroperitoneal hemorrhage following puncture of the aorta; however, death was thought to have resulted from the extremely severe hypertensive episode precipitated by the aortography. In a study of 36 patients in whom aortic punctures were performed, autopsy revealed blood outside the aorta in only 6. In no patient was the extravasation larger than a golf ball, and in the majority the puncture site was not detectable at autopsy.[9]

Techniques of Translumbar Aortography and Peripheral Arteriography

In order to obtain maximal benefit from aortography, the technique of the procedure must be standardized. Enemas and laxatives, if not contraindicated, should be given the day before. If local anesthesia is to be used for the study, the patient should be forewarned that he will feel a burning sensation descend from the abdomen to the feet, followed transiently by nausea and perhaps vomiting. The patient is placed in the prone position and 1% procaine hydrochloride is infiltrated subcutaneously, 7 to 8 cm. to the left of the midline and immediately below the 12th rib.[10,16] A 16-gauge needle is then advanced medially and slightly superiorly until the body of the first lumbar vertebra is contacted. The needle is then withdrawn slightly and progressively advanced anteriorly until the aorta is entered. The needle should be rotated 360 degrees to assure a good reflux in each position before the dye is introduced. A test dose of 10 ml. of the water-soluble medium sodium acetrizoate is injected rapidly, and a test film is made as the injection is terminated to ensure against malposition of the needle. For demonstration of the aorta, a pressure cuff may be inflated around each thigh in order to slow the aortic flow and aid in obtaining a higher concentration of dye in the aorta, but this is seldom necessary. For iliac, femoral, and popliteal visualization, prolonged exposures of two to five seconds allow the dye to be followed from the site of injection down to the popliteal area.

In performing a percutaneous puncture of the femoral artery for arteriograms, an initial injection of 3 to 5 ml. of dilute dye will allow one to ascertain the time for the flush reaction to reach the region of the midcalf or lower ankle. This will provide an indication as to when the exposures should be made to permit visualization of the entire arterial tree of the leg. The concentration of the dye for femoral arteriography should not exceed 35%.

Summary

This résumé has included the reported, untoward experiences with arteriography. Thousands of such studies have been uneventful and of definite benefit to as many patients. The incidence of significant injury is so low that, to date, complications from translumbar or peripheral studies have not been recognized on this service.

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Gastroscopy

An Evaluation of the Method

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Since the introduction of the flexible gastroscope in this country 23 years ago, gastroscopy has been widely employed, usually in conjunction with roentgenography, in the diagnosis of gastric ulcers and tumors. Two recent reports offer excellent background material on this subject.[2,3]

The present study, describing recent experiences with gastroscopy at the University of California Medical Center, was undertaken to define the usefulness of this procedure. In correlating the information obtained, special attention was given to situations where gastroscopy was of value in the detection, exclusion, or appraisal of gastric lesions and to others where it was misleading or noncontributory.

Methods

The records of 303 consecutive clinic patients who were examined by gastroscopy at the University of California Medical Center between January, 1952, and September, 1954, were reviewed. Of the 303 cases, 70 were considered unacceptable and were excluded from the series—25 because of insufficient follow-up information and 45 because of inadequate gastroscopy. Unsatisfactory examinations resulted from the following: inability to position the patient so that the gastroscope could be straightened sufficiently to give a round image (usually due to kyphosis), the presence of retained food, the formation of bubbles in the stomach, or poor patient cooperation. The remaining 233 cases were considered satisfactory for study; in each of these a final diagnosis was established at operation or autopsy or by follow-up periods of one year or longer.

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X-ray examination of the upper gastrointestinal tract preceded gastroscopy in all cases. In an effort to ensure an empty stomach, the gastric contents were aspirated through an Ewald tube immediately before gastroscopy. Premedications consisted of sodium phenobarbital, codeine, or meperidine, and local tetracaine (Pontocaine) with epinephrine. In the more recent cases silicone Antifoam tablets were given orally to reduce the occurrence of bubbles in the stomach.[1]

The Cameron Omni-Angle gastroscope, although it does not permit biopsy, was used for all examinations. In our experience gastroscopes which permit biopsy not only are large and cumbersome but do not provide entirely satisfactory visibility for routine work. The majority of gastroscopic studies were performed by residents or fellows in gastroenterology, with the assistance of an experienced gastroscopist. No accidents occurred, and the procedure was well tolerated by most patients.

Results

To aid in evaluation, the 233 cases in our series were first classified according to the results of the x-ray examination made prior to gastroscopy. The cases fell into the following groups: Group 1, benign gastric ulcer (42 cases); Group 2, carcinoma or polyp of the stomach (34 cases); Group 3, miscellaneous conditions (7 cases), and Group 4, negative x-ray reports (150 cases). The results of gastroscopy were then compared with those of the x-ray examination and the final diagnosis in each case. The diagnoses in Groups 1, 2, and 3 are listed in Table 1; the diagnoses in Group 4 are shown in Table 2. For purposes of further comparison, the cases in which the gastroscopic report was negative were also tabulated (Table 3).

Group 1: X-Ray Report of Benign Gastric Ulcer (42 Cases).—Gastroscopic examination in 17 patients confirmed the presence of

TABLE 1.—*Gastroscopic and Final Findings in Eighty-Three Cases with Positive X-Ray Reports*

No. of Cases	X-Ray Examination	Gastroscopy	Final Diagnosis
Group 1: X-Ray Report of Benign Gastric Ulcer (42 Cases)			
19	Gastric or jejunal ulcer	Benign ulcer	Benign ulcer
11	Gastric ulcer	Negative	Negative (prominent rugae)
6	Gastric ulcer	Negative	Benign ulcer
3	Gastric ulcer	Negative	Benign ulcer ?
2	Stomal ulcer (?)	Negative	Stomal ulcer
1	Stomal ulcer	Negative	Stomal ulcer
Group 2: X-Ray Report of Carcinoma or Polyp (34 Cases)			
19	Carcinoma	Negative	Negative (prominent rugae)
1	Polypoid malignancy	Benign polyp	Benign polyp
3	Carcinoma (?)	Benign ulcer	Benign ulcer
1	Carcinoma	Leiomyoma	Leiomyoma
1	Adhesions, carcinoma or lymphoma	Benign polyp	Benign polyp
5	Carcinoma (?)	Carcinoma (?)	Carcinoma, 1; benign lesions, 4
1	Carcinoma	Carcinoma	Carcinoma
1	Carcinoma, infiltrating	Negative	Carcinoma
1	Multiple benign polyps	Negative	Multiple benign polyps
1	Polyps	Negative	Negative
Group 3: Positive X-Ray Report, Miscellaneous (7 Cases)			
6	Gastritis	Negative	Negative
1	Diverticulum	Negative	Negative

a benign gastric ulcer previously identified roentgenographically and either called benign or not specified. In 20 patients in whom gastric ulcers had been seen or suspected by x-ray examination, no lesions were detected gastroscopically. In six of these a benign ulcer was found at operation and was undoubtedly present but not seen at the time of gastroscopy. In 3 of the remaining 14 patients ulcers may have been present in areas that could not be seen with the gastroscope. In the other 11 cases ulcers were ruled out by gastroscopy. These were usually instances of large rugae, resembling ulcer niches, along the lesser curvature of the stomach. Two roentgenographically observed jejunal ulcers were confirmed gastroscopically. In one patient in whom a stomal ulcer was seen by x-ray examination, the gastroscopy report was negative. Gastroscopic examinations were also negative in two patients with suggestive x-ray evidence of stomal ulcer; because of their symptoms and the knowledge that a stomal ulcer may be out of range of the gastroscope, we presumed that the x-ray diagnosis was correct.

TABLE 2.—*Gastroscopic and Final Findings in 150 Cases with Negative X-Ray Reports*

No. of Cases	Gastroscopy *	Final Diagnosis
2	Carcinoma	Carcinoma
1	Ulcer (? malignant)	Benign ulcer
2	Stomal ulcer	Stomal ulcer
1	Ulcer scar	Healed ulcer
1	Benign polyp	Benign polyp
2	Diaphragmatic hernia	Diaphragmatic hernia
141	Negative	Negative

* The number of patients whose x-ray reports were negative but who were found to have gastritis by gastroscopy were not tabulated.

In brief, of 42 x-ray examinations in which the issue was that of gastric or stomal ulcer, the gastroscope confirmed the presence of a benign ulcer in 19 instances. Six benign gastric ulcers and three stomal ulcers were not detected by gastroscopic examination; it seems most likely that the three stomal ulcer were missed because they were beyond the range of the gastroscope. In 11 patients the x-ray impression of a benign ulcer was shown to be in error.

Group 2: X-Ray Report of Carcinoma or Polyp of the Stomach (34 Cases).—Carcinoma was excluded by gastroscopy in 25 cases. In 19 instances it was found that the roentgenographic impression resulted from the presence of large gastric rugae, with or without hypertrophic gastritis. In the remaining 6 of these 25 cases, the findings were as follows: Gastroscopy demonstrated a benign polyp in one case in which a polypoid malignancy had been diagnosed by x-ray. Three patients whose x-ray examinations were reported as showing probable carcinoma were found at gastroscopy to have benign ulcers; in two of these patients

TABLE 3.—*X-Ray and Final Findings in 193 Cases with Negative Gastroscopic Reports*

No. of Cases	X-Ray Examination	Final Diagnosis
1	Carcinoma (infiltrating)	Carcinoma
1	Multiple benign polyps	Multiple benign polyps
3	Gastric ulcer	? Benign ulcer
6	Gastric ulcer	Benign ulcer
1	Stomal ulcer	Stomal ulcer
1	Diverticulum	Diverticulum
19	Carcinoma	Negative (prominent rugae)
11	Gastric ulcer	Negative
2	Jejunal ulcer	Negative
1	Polyps	Negative
6	Gastritis	Negative
141	Negative	Negative

the suspected lesion was not identified as an ulcer by x-ray. Carcinoma was misdiagnosed roentgenographically in one patient who was shown by gastroscopy to have a leiomyoma. In one case in which roentgen findings led to a suggested diagnosis of adhesions, carcinoma, or lymphoma a benign polyp was found by gastroscopy.

Five patients in whom carcinoma had been considered possible or probable by x-ray examination were thought "probably" to have carcinomas by gastroscopy. Gastric resection confirmed the presence of carcinoma in one, whereas three patients were found to have benign lesions. The fifth patient refused to undergo gastric resection; two and one-half years later he was found to be asymptomatic. In an additional case gastroscopy resulted in better evaluation of a carcinoma detected by x-ray.

An x-ray diagnosis of an infiltrating type of carcinoma was made in one patient; the gastroscopist, however, considered the stomach normal, but the initial diagnosis of gastric carcinoma was confirmed at operation. Multiple benign polyps were seen in one patient by x-ray and later at operation, but were not seen gastroscopically. In the final patient in this group polyps were excluded by gastroscopy, although they had been strongly suspected on the basis of the x-ray examination.

To recapitulate, in 34 instances in which the problem of carcinoma or polyps was considered on the basis of x-ray findings, the lesion was excluded by gastroscopy in 26 cases and confirmed in 2. In four cases in which both the x-ray and the gastroscopic examinations suggested possible or probable carcinoma, the presence of carcinoma was confirmed by gastric resection in only one; no malignancies were found in the remaining three patients. In the final two cases in which the gastroscopic report was negative, surgery confirmed the x-ray diagnosis of carcinoma in one patient and of multiple benign polyps in the other. In no instance was a malignancy misdiagnosed gastroscopically as a benign tumor.

Group 3: Miscellaneous (7 Cases).—Gastritis was diagnosed by x-ray in six patients and a gastric diverticulum in one. In all seven cases the abnormalities were ruled out by gastroscopy.

Group 4: Negative X-Ray Report (150 Cases).—In 9 of the 150 cases, the negative roentgenographic report was in error (Table 2); both the gastroscopic and the final diagnoses were carcinoma in two patients, ulcer in four (one healed), and a benign polyp in one. A diaphragmatic hernia was found by gastroscopy in the remaining two patients. This is unusual, since ordinarily the x-ray procedure is superior to gastroscopy in the detection of this condition.

In the 141 cases comprising the rest of the series, both roentgenographic and gastroscopic findings and the final diagnosis were negative, with the exception of some instances of the various types of gastritis, the clinical significance of which is beyond the scope of this paper. Gastroscopy was performed in these patients despite negative x-ray examinations because of clinical indications of a possible gastric ulcer or tumor (abdominal pain, anorexia, loss of weight, or primary or secondary anemia).

Summary

The chief clinical use of gastroscopy is in the detection, exclusion, or evaluation of gastric ulcers and tumors. Evidence obtained in the present series of 233 patients, all of whom had been followed for periods of one year or longer, shows the value of this method as a complement to the diagnostic x-ray procedure.

Of 42 cases in which the x-ray diagnosis was that of benign ulcer, this report was found by gastroscopy to be in error in 11 (26%). Of 34 cases in which the x-ray report indicated or suggested carcinoma or polyp, such lesions were excluded by gastroscopy in 25 (74%). On the other hand, of six instances in which the gastroscopist considered the possibility or probability of malignancy, carcinoma was found in only two. One diffusely infiltrating car-

cinoma was missed gastroscopically. In no case in this series was a malignancy misdiagnosed gastroscopically as a benign tumor.

Review of the 150 cases in which the x-ray report was negative showed that gastroscopy led to the detection of two carcinomas, four ulcers, and one benign polyp. On the basis of these data, one may expect to find a lesion in 6% of cases in which the x-ray report is negative.

The gastroscopic report was in error in only 13 of our 233 cases, and possibly erroneous in another 3 cases, in which the x-ray diagnosis was benign ulcer. In the latter three cases the lesions may have been located in an area which could not be visualized with the gastroscope.

Conclusions

1. Gastroscopy is a valuable diagnostic adjunct to the x-ray examination.

2. It is indicated when there is symptomatic evidence of gastric ulcer or tumor with or without x-ray evidence of abnormality.

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Fatty Infiltration of Parotid Glands

Report of a Case

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Introduction

The purpose of this paper is to report an apparently heretofore unrecorded condition of bilateral fatty infiltration of the parotid gland which simulated neoplasm.

A review of the *Cumulative Index Medicus* for the past 20 years reveals only one reference [1] to a related lesion, which was reported as a nodule of fatty infiltration in one parotid. Lang [2] mentions fatty infiltration under the designation of lipomatosis. No mention is made of this condition in a fascicle entitled "Tumors of the Major Salivary Glands," [3] and Foote [4] states that he has not encountered a similar lesion. Rawson et al.[5] mentioned one case of lipoma without further comment. Payne [6] stated that lipomata are particularly likely to occur in the parotid. This case is reported because of its rarity and resemblance to other lesions occurring bilaterally, such as papillary cystadenoma lymphomatosum, mixed tumor, benign lymphoepithelial lesion, and masseteric hypertrophy.

Report of Case

A 52-year-old white woman noticed progressive enlargement of both parotid areas over a period of six months. This was accompanied by slight pain. There were no other significant manifestations.

The patient weighed 171 lb. (27 kg.) and was about 5 ft. 5 in. (162.5 cm.) in height. The historical review and physical examination were of no additional significance.

In October, 1956, the right parotid area was explored and the superficial and a portion of the deep part of the parotid were removed. Grossly the specimen was covered by a thin capsule and measured 7×5×2 cm. A second, smaller fragment measured 4×2×1 cm. Sectioning revealed the entire specimen to be composed of lobular, moderately firm, yellow tissue.

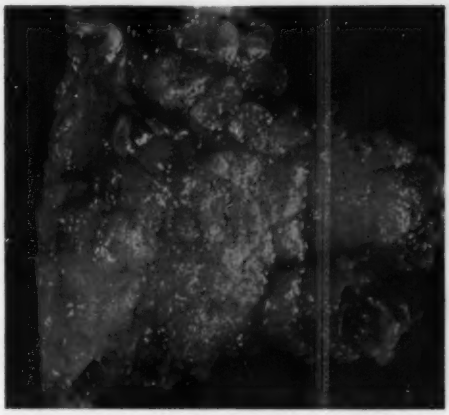

Fig. 1.—Gross specimen showing lobulations composed largely of fat.

Several months later, on Feb. 28, 1957, a similar surgical procedure was performed on the left parotid, and a specimen measuring 7.5×5.5×2 cm. was removed (Fig. 1). It resembled the first specimen.

Microscopically the tissue was composed of normal-appearing fat cells separating normal-appearing ducts and acini (Fig. 2). The process of fatty infiltration was diffuse, appearing in all random sections.

At the present time, about one year since operation, the patient has no recurrence or other difficulty related to the parotid glands.

Comment

A case of a heretofore undescribed salivary-gland lesion of diffuse fatty infiltration is reported which simulated bilateral neoplasm.

There was no apparent cause of the fatty infiltration. The patient was large but not

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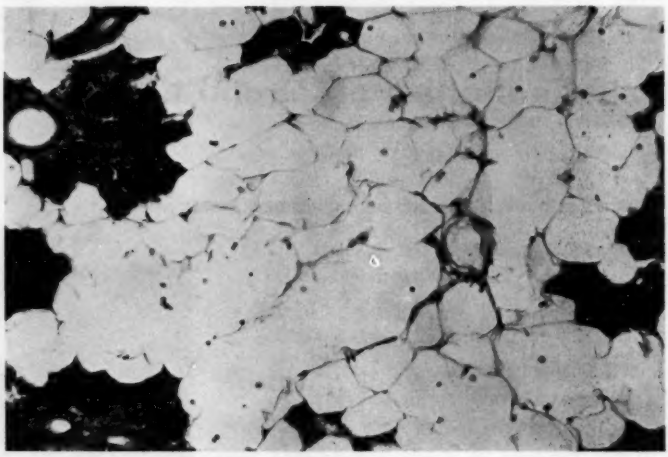

Fig. 2. — Photomicrograph showing separation of glandular tissue by wide areas of fat. Hematoxylin-eosin stain; reduced to 63% of mag. × 310.

overly obese. There were no stigmata of other diseases which might conceivably have been associated with this process.

At the present time the patient is well and has no symptoms or signs referable to the parotid glands.

Summary

A case of fatty infiltration of the parotid glands is reported. No similar case was found in a review of the English literature for the past 20 years.

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Solitary Cecal Diverticulitis

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Acute inflammation in a solitary diverticulum of the cecum is an entity which has not gained wide enough recognition, in spite of the many case reports which have appeared since it was first reported by Potier,[9] in 1912. The incidence of all diverticulosis of the colon is said to be between 5% and 8%.[10,14] Only about 2% of this number occur as solitary diverticula of the cecum.[2] Thus, statistically, cecal diverticulum is a very uncommon, if not rare, lesion, which seldom is mentioned in surgical textbooks. Failure of recognition of the lesion has led, in some instances, to radical surgery, which may have been unnecessary had the surgeon been aware of this condition at the time of operation.

Anderson,[1] in 1947, reviewed the entire literature and found reports of 91 cases of diverticulitis of the cecum and added 8 cases to this list. It is particularly interesting to note that of the 91 patients that were reported, 18 had a right colectomy, of whom 2 died postoperatively, and 14 had a cecectomy, of whom 2 died postoperatively. Many other, less extensive procedures were performed, including simple excision, simple closure of a defect, inversion of the diverticulum, exteriorization after the method of Mikulicz, and simple drainage.

Pathologically, there are no unusual aspects, except that the lesion occurs as a single diverticulum, located usually on the cecum and occasionally on the ascending colon. It may be (1) a true congenital diverticulum, which contains all layers of the bowel, or (2) a false diverticulum, occurring at a weakened spot in the cecal wall in which the muscularis is absent.[4,5,7] The process of inflammation begins when impacted fecal material collects inside the diverticulum until it attains a size sufficient to cause ulceration, often proceeding to perforation. This process usually progresses slowly and is well walled off.

There is nothing in the clinical course of this disease to differentiate it from appendicitis, although its progress tends to be slower and less severe. There have been few reports[6,11] of preoperative diagnosis of the condition, and these usually in cases in which appendectomy had already been done.

The following three cases were seen in the course of one year, no others having been encountered in the preceding 18 years in surgical practice.

Report of Cases

CASE 1.—A 49-year-old white woman was admitted to Mount Sinai Hospital with the history of onset of generalized abdominal pain 48 hours previously, with localization to the right lower quadrant 24 hours later. She had slight nausea and anorexia but no vomiting. Temperature on admission was 99.4 F; pulse, 120 a minute; WBC, 19,950 per cubic millimeter, with a slight shift to the left. Examination of the abdomen showed marked tenderness in the right lower quadrant, with no rigidity but with slight rebound tenderness. The rectal examination was negative. Pelvic examination showed tenderness toward the right side. A preoperative diagnosis of acute appendicitis was made, and the patient was taken to surgery one hour after admission. A right pararectus incision was made. Upon mobilizing the cecum, it was found to contain a hard, indurated, inflammatory mass on its anterior surface adjacent to the ileocecal valve. The mass was not connected to the appendix, which was not involved in the primary pathology. A few loops of small bowel were loosely adherent to the inflammatory mass. When these were removed, several fat pads arising in the ileocecal region were found to be adherent to this portion of the cecum and involved in hard induration. When these were dissected away, there remained a single mass, about the size of a small olive. Further dissection revealed that it was a

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diverticulum, with a small opening into the cecum. The diverticulum was resected from the cecal wall and was removed. The small opening in the cecum was then closed with a purse-string suture and further reinforced with mattress sutures. A portion of the ileocecal fat pad was sutured over the involved area. The appendix was removed, and the abdomen was closed in layers without drainage. The microscopic report follows: Sections from the diverticulum show it to be "lined with hyperplastic but uniform mucosa. In some places the submucosa is preserved. In most others the entire wall has undergone hemorrhagic infarction. In one area an ulcer is present, which apparently has perforated through all layers of the wall. The edges are covered with a heavy leukocytic and fibrinous exudate. We are dealing here with a perforated diverticulum of the cecum."

The patient's postoperative course in the hospital was uneventful, and she was dismissed on the seventh postoperative day. A follow-up barium enema study showed no further diverticula.

CASE 2.—A 43-year-old white man was admitted to Mount Sinai Hospital complaining of abdominal pain of about five days' duration. On the day prior to admission the pain became severer in the lower part of his abdomen and seemed to shift to the right side. Temperature on admission was 99.6 F; pulse, 90 per minute; WBC, 13,850 per cubic millimeter, with a slight shift to the left. Urinalysis was negative. Palpation of the abdomen showed marked tenderness in the right lower quadrant, which seemed to localize at McBurney's point. There was no muscle spasm, and no mass was palpable. A diagnosis of acute appendicitis was made, and the patient was taken to surgery. A McBurney incision was made. Upon mobilization of the cecum, a hard, indurated mass was apparent on its anterior wall 2 cm. from the ileocecal valve. The entire mass was about 5 cm. in diameter and appeared to be inflammatory, with considerable overlying indurated fat. The appendix was mobilized and found to be slightly inflamed, but this process was not considered primary. After careful dissection, it was possible to identify a diverticulum lying under the indurated fat tissue. This was dissected down to a very narrow neck and was removed. A purse-string suture was passed to close the opening thus made in the cecum. The ileocecal peritoneal fold was sutured over this closure of the cecal wall. Routine appendectomy was performed. The pathological report was as follows: "The diverticulum contains a fecolith and shows acute, diffuse, suppurative inflammation with perforation."

The patient's course in the hospital was uneventful, and he was discharged on the sixth postoperative day. A barium enema study was done subsequently, and the colon was reported as normal.

CASE 3.—A 38-year-old man gave a history of mild pain in the right lower quadrant for three days prior to his consulting a physician. He was otherwise well, but pain was slowly becoming worse and was constant. On examination there was pointed tenderness in the right lower quadrant, with rebound tenderness. Bowel sounds were normal. No muscle spasm or masses were noted. The blood count and urinalysis were normal. At operation, a hard, somewhat indurated mass was noted on the anterior wall of the cecum, not associated with the appendix. After freeing the adherent bowel, a pea-sized diverticulum was found, which showed a pinpoint perforation and contained a hard fecolith. It was removed, and the defect closed with a purse-string suture and then covered with the redundant ileocecal fat pad. The appendix was normal but was removed. Convalescence was uneventful.

Comment

The diverticula in the cases reported, fortunately, were comparatively small and occurred on the anterior wall of the cecum. The diagnosis, therefore, was simple, as well as the treatment by excision. The various reports show that the size of such diverticula may range from 1 cm. in diameter up to that reported by O'Callagham,[8] which was said to be "the size of a child's head." These larger diverticula, with massive inflammatory reactions, are the ones that have led experienced surgeons to believe they were dealing with a carcinoma; therefore, they have done radical surgery at the time of the initial operation. It is also noted that these lesions may occur on any portion of the cecum, and it is in those occurring on the posterior, or retroperitoneal, wall that it will become increasingly difficult to ascertain whether the primary condition is inflammatory or neoplastic. It has been suggested by Updegrove[13] that if the lesion cannot be well visualized, the cecum may be opened and the ostium be sought to establish a diagnosis. This would enable the surgeon to rule out carcinoma and avoid radical excision for a doubtful lesion. The approach is admittedly undesirable but on occasion will be worth the risk of contamination.

The majority of diverticula of the cecum can be treated by simple excision, using a

purse-string suture for closure. A diverticulum is usually smaller than the inflammatory mass which is at first noted, and by careful, somewhat blunt, dissection it can be freed from the cecal wall until a very small opening is found. Some treat diverticula with inversion [3] or, if inflammation is too great, and no manner of closure can be effected, a cecostomy.[12]

Conclusions

1. Acute solitary diverticulitis of the cecum is a condition which can rarely be diagnosed preoperatively.

2. This condition will frequently be considered of neoplastic origin, owing to the mass of inflammation surrounding it, and a more radical procedure will be done than is necessary.

3. Treatment of the majority of these diverticula should consist of simple excision and closure of the base by reinforcement with omentum or the ileocecal fold of peritoneum.

4. In operating upon a patient who has had a typical clinical appendicitis in which the appendix is not believed to be the cause of the symptoms, the cecum should be carefully examined for the presence of a diverticulum, as such a lesion frequently occurs under a peritoneal fold or retrocecally, where its diagnosis cannot be obvious.

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Gallstone Ileus in the Absence of Biliary Fistula

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One of the more uncommon causes of acute intestinal obstruction is impaction of a gallstone in the intestinal lumen. Almost without exception, this is the result of a spontaneous internal biliary fistula, occurring most frequently between the gallbladder and the duodenum. A gallstone ileus, in the absence of a previous communication between intestine and biliary tree, is, however, a rare occurrence; only two such cases have been discovered in the literature. The site of formation of the stone in one of these cases was a duodenal diverticulum [1] and in the other a blind duodenal stump following subtotal gastrectomy.[2]

It is the purpose of this report to review briefly the problem of gallstone obstruction of the intestinal tract and to present a third case of acute intestinal obstruction resulting from impaction of a large gallstone in the terminal ileum in the absence of a previous biliary-tract fistula.

Incidence

In 1951 McLaughlin and Raines [3] tabulated the various reports of intestinal obstruction due to gallstones and added a group of four such cases. Of 19,692 cases of intestinal obstruction, 366, or 1.9%, were due to a gallstone. Women were more frequently afflicted, the ratio being similar to that for cholecystitis, namely, 7 women to 1 man. Wakeley and Willway [4] state that there is a history of biliary disease in 30% to 50% of cases of gallstone ileus, while others report that a pertinent previous history is infrequent.[5,6] It is a condition that occurs most frequently in the elderly patient during the sixth or seventh decade of life.[7]

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Pathogenesis

There is uniform agreement that a biliary calculus large enough to cause intestinal obstruction will usually enter the gastrointestinal tract by way of a cholecystoenteric fistula. The most frequently found communication is that between the gallbladder and the duodenum; Wakefield et al.[8] reported 101 such instances in a review of 176 cases of cholecystoenteric fistulae. Also, not uncommonly involved are the colon and stomach, while rather bizarre instances have been recorded of gallstones extruding into the free peritoneal cavity and eroding into the renal pelvis, bladder, uterus, vagina, ovarian cysts, portal vein, and pericardium, and even through the diaphragm into the lung parenchyma and bronchial tree.[9] A gallstone impacted in the distal portion of the common duct may erode its way through the adjacent duodenum by pressure necrosis and form a choledochoduodenal fistula. Rarely, invasion by carcinoma of the gallbladder, stomach, or colon may result in a biliary-gastrointestinal tract communication.

Thus, some form of internal biliary fistula has been or is almost always present when intestinal obstruction from gallstone is encountered. A rare exception to this will sometimes occur when a stone passes through a normal common duct and lodges in a blind pouch (diverticulum or duodenal stump following gastric surgery, as in the cases mentioned), where it may reside and enlarge; it may subsequently dislodge and become impacted somewhere in the gastrointestinal tract. Wangensteen [10] feels that this is a definite possibility. There seems little doubt that a gallstone can enlarge when retained chronically in the intestinal tract, especially in the large bowel. This was rather dramatically illustrated by the huge

gallstone removed from the transverse colon by Turner [11]; the stone was 7.5×6.3×17.5 cm. and weighed 5 oz. (150 gm.). In this, and other cases reported, a fistula was demonstrated or, at least, seemed quite likely when at operation it was found that the duodenum, stomach, or colon was adherent to the gallbladder or common duct.

Symptoms

The clinical picture of gallstone ileus is identical with that of any other mechanical intestinal obstruction. The term ileus is perhaps poorly chosen, since it implies an adynamic state. This, of course, may be true in long-standing intestinal obstruction regardless of etiology, but it is not the initial process in obstruction due to gallstone. Rather, the patient will complain of cramping, abdominal pain, occasionally localized, often diffuse. It is not unusual to have periods of freedom from pain; the probable explanation is that the spasm accompanying the passage of the stone causes transient obstruction, which is relieved as the spasm subsides. This allows the calculus to pass farther to its ultimate site of impaction, at which time signs and symptoms of complete obstruction appear. High-pitched bowel sounds with hyperactive peristaltic rushes are heard. There may be diffuse tenderness, but seldom can a mass be felt or localizing signs be elicited. Nausea and vomiting are present, and, in long-standing cases, fecal vomitus is common. Here, too, distention becomes apparent, and the patient may deny any bowel movement or passage of flatus from the onset of his symptoms. If the obstruction occurs quickly after formation of the internal biliary fistula, the patient may also have symptoms associated with an exacerbation of biliary-tract disease.

Diagnosis

Occasionally, but not often, the diagnosis of intestinal obstruction from gallstones can be logically entertained. When the cause of intestinal obstruction is obscure, especially in the aged, and even more so in those with a previous history of gallbladder disease, gallstone obstruction should be suspected. In such instances close inspection of abdominal films may show an opaque biliary calculus as the offending agent. Such studies may also show air in the biliary radicles, indicating an internal biliary fistula (Fig. 1), as pointed out by Rigler et al.,[12] which would increase the likelihood of an obstructing gallstone. In all probability, this diagnosis would be made more frequently before operation if impacted gallstones were thought of as a cause—unusual, but certainly far from rare—of intestinal obstruction.

Fig. 1.—Air in the external biliary tree establishes the diagnosis of an internal biliary fistula. This was not present in the case reported.

Treatment

As soon as a diagnosis of obstruction has been clearly established by the history, physical examination, and roentgenographic study, immediate preparation for laparotomy is indicated. Although the patients are usually seen relatively late in the course of their disease, this condition should be considered a surgical emergency. Delay in treatment of these patients must certainly be an important factor in a mortality rate of 40% to 60%. Immediate preoperative treatment consists of intravenous restoration of fluid and electrolyte deficiencies, blood transfusions, if indicated, and passage of a nasogastric or intestinal tube. At operation, the obstructing stone can usually be readily identified; it rests most frequently in the terminal ileum, although it can lodge in other sites in the intestine. In cases collected

by Courvoisier,[13] the obstruction was found in the duodenum or jejunum in 21.4% of the cases, in the ileum in 65.4%, at the ileocecal valve in 10%, and in the sigmoid flexure in 2.4%.

It has been advised by some surgeons that the stone should be milked proximally into the dilated bowel, where a longitudinal enterotomy with extrusion of the foreign body can be performed. Others feel that often this is not technically possible, or that it is unwise to render additional trauma to the bowel by such manipulation, and that enterotomy over the impacted stone should be performed. It has also been suggested that the stone be crushed with a forceps and the fragments allowed to pass spontaneously. It would seem, however, that this maneuver would entail unwarranted injury to the intestine. Following enterotomy, a transverse, two-layer closure of the longitudinal incision is performed. In the case to be reported, the incision in the bowel was made in a markedly dilated proximal intestine, so that longitudinal closure was easily performed without danger of compromising the lumen. Generally, however, a transverse closure is to be preferred. Caution must be exercised in preventing fecal contamination of the peritoneal cavity during enterotomy.

Also worthy of note are the occasional instances of multiple obstructing gallstones [4] or recurrent obstruction,[14] indicating overlooked stones at the time of initial laparotomy. It behooves the surgeon, therefore, to be sure that he has completely eliminated the cause of the obstruction by inspection of the bowel throughout its entire length.

Definitive treatment of the internal biliary fistula is probably unwise at the time of initial exploratory laparotomy. Sometimes persistence of the fistula may cause subsequent symptoms and necessitate another operation. Many such fistulae, however, close spontaneously and never require further surgical treatment.[15] As stated above, the patient with gallstone ileus is usually seen late in the course of his disease, when his general physical condition is far from ideal. It is unwise to prolong the operation and subject the patient to additional surgery at this time. A secondary, elective operation may be performed to close the fistula if necessary.

As has been mentioned, the operative mortality reported in the literature for intestinal obstruction due to gallstone varies between 40% and 60%. This high rate is probably a result of (1) failure to establish an early diagnosis, (2) the advanced age of the average patient so afflicted, and (3) failure to make an aseptic enterotomy, as suggested by Wangensteen.[10] More recent reports suggest a current mortality from this condition of approximately 15%.[3]

Report of a Case

A 68-year-old white woman was admitted to the University of California Hospital, with a five-day history of intermittent, cramping abdominal pain, nausea, and vomiting. She had passed little flatus and no stool during that time. One and one-half months prior to admission, she had an exploratory laparotomy at another hospital for epigastric and right upper quadrant pain, nausea, and vomiting, the condition being diagnosed as acute cholecystitis. At operation, a "firm, hard, indurated and inflamed pancreas, as well as an infected and distended gallbladder full of stones," was found. Because of the marked inflammatory response in the right upper quadrant, it was felt unwise to perform a cholecystectomy at that time. Consequently, the gallbladder was drained and the stones removed. The postoperative course was uneventful until five days prior to the present admission, when signs of acute intestinal obstruction occurred.

The past history was significant, in that a subtotal gastrectomy for carcinoma of the stomach had been performed 20 years prior to admission and a total hysterectomy for fibroids 15 years prior to admission. In the intervening years, no symptoms referable to the pelvic organs or stomach nor any symptoms suggestive of gallbladder disease had occurred.

Upon examination, the temperature was 37.4 C (99.3 F), the pulse 80, the respiration 15, and blood pressure 190/96. The patient was a thin, normally developed white woman, who appeared ill and suffered from periodic episodes of severe intestinal colic; marked borborygmi occurred with the colic. There was some distention and minimal diffuse tenderness of the abdomen. No masses were palpable, and no fluid was detectable. There was

Fig. 2.—Distended loops of small bowel with air-fluid levels confirm the clinical impression of intestinal obstruction.

a well-healed upper midline and right subcostal scar. Rectal examination was negative.

Laboratory studies included a hemoglobin of 14 gm. per 100 cc., a white cell count of 6800 per cubic millimeter, negative urinalysis, and a serum amylase of 67 units per 100 cc. The electrolytes were within normal limits. Flat and upright roentgenograms of the abdomen revealed several air-fluid levels in dilated loops of small bowel (Fig. 2) present in the left lower quadrant of the abdomen. No radiopaque objects were discernible,

Fig. 3.—The obstructing calculus is in the distal ileum. The proximal bowel is quite distended, while the distal bowel is collapsed.

and no air was present in the biliary tree. Findings were quite obviously those of an acute mechanical intestinal obstruction.

The patient was intubated and hydrated, and an exploratory laparotomy was carried out through a right subcostal incision, extending across the left rectus muscle. The peritoneal cavity contained 300 to 500 ml. of nonodorous, amber-colored fluid. The entire small bowel was distended down to approximately 15 in. from the ileocecal valve, where a hard, spherical intraluminal mass completely obstructed the lumen of the ileum. Distal to the obstruction the ileum was collapsed (Fig. 3). There was no question of the viability of the bowel. The mass was freely movable and obviously was not a small-bowel tumor but, rather, a foreign body. The mass was easily milked a distance of 10-12 in. proximally, the bowel was occluded proximally and distally with noncrushing, rubber-shod intestinal clamps, and a longitudinal antimesenteric ileotomy was performed (Fig. 4). A large, 2.5×4 cm. calculus was extruded; on cut section it proved to be concentrically laminated (Fig. 5). Subsequent analysis revealed that it was

Fig. 4.—Artist's conception of surgical management of the impacted gallstone. The foreign body is milked into the dilated proximal ileum and extruded through a longitudinal enterotomy.

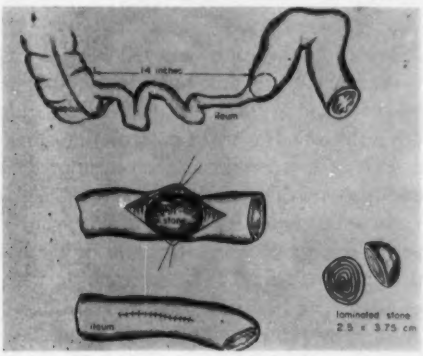
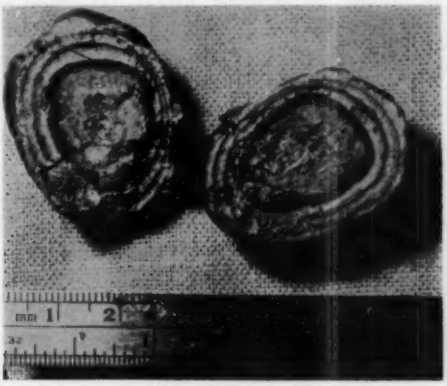


Fig. 5.—Laminated gallstone removed from terminal ileum, measuring 2.5-4 cm.



composed of amorphous debris with yellow-brown pigment and cholesterol crystals, identifying it as a gallstone. The ileotomy was closed longitudinally in two layers without compromise of the lumen; the inner muscular layer of continuous 000 chromic absorbable surgical (gut) was reinforced by interrupted 0000 silk sutures in the seromuscular layer. Palpation of the remainder of the small bowel disclosed no additional stones. Because her condition preoperatively and during surgery was very good, it was felt justifiable to explore expeditiously the right upper quadrant and epigastrium in an effort to identify a biliary-enteric fistula. Numerous adhesions bound a somewhat distended but intact gallbladder to the peritoneum and hepatic flexure of the colon. These were carefully lysed, and no evidence of a cholecystocolic fistula could be found. The subtotal gastrectomy performed 20 years previously had utilized a Billroth II type of gastrojejunostomy. The efferent and afferent limbs were normal, with no suggestion of fistulous connection between them. The pancreas was soft and normal in consistency and appearance. The duodenum was not adherent to the gallbladder at any point and was entirely free of any evidence of recent or old communication with the gallbladder. The common duct was small and of normal size; palpation revealed no stones. Nor were there any stones in the gallbladder. A routine cholecystectomy was performed. The abdomen was drained and closed in layers. The postoperative course was entirely benign, and the patient was discharged 10 days postoperatively.

Comment

In many respects this case is quite representative of the usual patient with a gallstone obstruction of the bowel. The patient was an elderly woman with a typical history and findings of acute mechanical intestinal obstruction, a diagnosis that was obscure preoperatively, and an obstruction found at operation in the terminal ileum. The remarkable feature of the case was the absence of an internal biliary fistula at operation, with no indication that one had ever been present. It became clear then that the stone must have been passed through the common duct into the gastrointestinal tract, where it lodged and enlarged. It is also conceivable that the calculus formed in situ in the blind duodenal stump. In the absence of any diverticula of the small bowel demonstrable at surgery, it seems logical to assume that the stone entered the

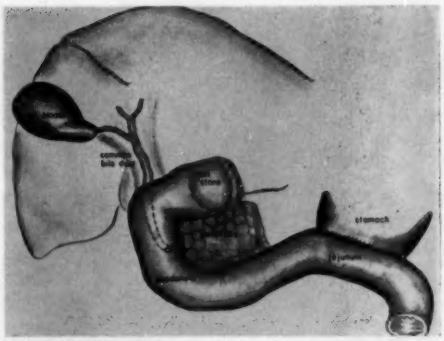


Fig. 6.—Obstructing stone presumably resided and enlarged in the blind duodenal stump. Manipulation dislodged it into the intestinal stream with subsequent impaction in terminal ileum.

duodenal stump sometime after the Billroth II gastric resection for carcinoma of the stomach, 20 years previously. At the first exploration for suspected biliary-tract disease, it would seem that the "firm, hard mass" in the region of the head of the pancreas was in fact the intraduodenal gallstone (Fig. 6). Manipulation in this area must have dislodged it, with gradual migration in the subsequent six weeks to its site of impaction in the terminal ileum. Despite the delay of several days in diagnosis, her bowel showed no sign of gangrene. She tolerated the procedure well and made an uneventful recovery.

We have been able to find only two other cases in the literature in which gallstone obstruction occurred in the absence of a biliary fistula. Dulin [1] reported a case in which a large stone probably had formed in a duodenal diverticulum and subsequently caused a fatal mechanical intestinal obstruction.

Similar to the case reported here is that of Warner and Swan,[2] in which the patient also had had a previous gastric resection with a Billroth II type of gastrojejunostomy, as well as a previous cholecystectomy. He developed mechanical intestinal obstruction many years following this surgery, and at operation a gallstone obstruction of the distal ileum was found. The common duct was not dilated, and no sign of an internal biliary fistula was present. The authors assumed

that the stone had formed in the blind duodenal stump with subsequent migration to its point of impaction. It is suggested by these authors that this might be listed as an unusual or unique complication of gastric surgery.

Summary

Gallstone ileus is one of the more uncommon causes of acute intestinal obstruction. This complication almost always follows the formation of an internal biliary fistula. The pathogenesis, clinical picture, and treatment of this disease are discussed.

An unusual case of an elderly woman with an acute gallstone ileus occurring in the absence of a fistulous communication between the biliary and intestinal tracts is presented. It is proposed that this represented a late complication of a gastric resection with a Billroth II type of gastroenterostomy, the stone having formed or enlarged in the blind duodenal stump.

A review of the literature reveals only one similar case.

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Blind-Pouch Formation Following Lateral Anastomosis

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Side-to-side anastomosis is an expedient method for reestablishing intestinal continuity after resection. However, this procedure may be followed by a unique complication, which does not occur after the end-to-end or end-to-side technique. Infrequently, saccular dilatation develops in the portion of the proximal segment of intestine that projects beyond the anastomotic stoma. This is not necessarily due to leaving in an excessively long blind end. A closed section no longer than an inch beyond the stoma may develop into a large dilatation. This complication is illustrated in the first case reported.

Report of Cases

CASE 1.—A 63-year-old white man was admitted to the hospital on July 18, 1956. Apparently in good health, he suddenly fainted after eating his dinner. When he became conscious, he vomited bile-stained food, and brownish-red blood was found oozing from the rectum. His skin was moist and cold. Oral temperature 98 F; pulse 64 per minute; respirations 16 per minute. Blood pressure 70/40 mm. Hg. Hgb 62%; WBC 21,100 per cubic millimeter; hematocrit 31%; prothrombin time 32%; clotting time (Lee and White) 11 minutes 30 seconds; platelet count 154,000 per cubic millimeter. The stools contained blood for only two days.

He had been operated upon on May 3, 1943, for a mucoid carcinoma of the cecum. There were numerous small metastases over the mesentery of the ascending colon, and a few nodules were seen in the root of the mesentery of the small intestine. The terminal 2 ft. of the ileum and the right half of the colon were resected. A side-to-side, isoperistaltic ileocolostomy was performed, with the closed end of the ileum extending ¾ in. beyond the stoma. The inverted end of the colon was left 1½ in. long. The patient had an excellent recovery, and he remained perfectly well until the onset of the fainting episode.

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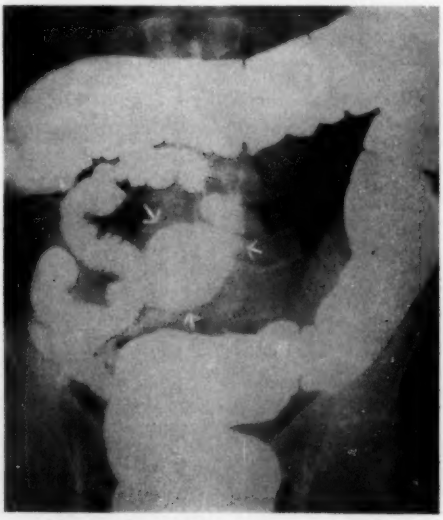
Barium enema examination was performed Feb. 7, 1951, during a routine physical examination, and it was repeated on July 23, 1956. These gave similar findings: "The ileocolostomy functions well. The closed end of the ileum projects as a diverticulum 6 in. beyond the ileocolic opening. Its distal third, which is dilated to twice the diameter of the terminal ileum, forms a sac devoid of peristalsis. The closed end of the transverse colon is about 2½ in. long" (Fig. 1).

The patient was operated upon on Aug. 8. The closed end of the ileum projected as a pouch beyond the anastomotic stoma. It measured 5 in. in length, and its base was 1 in. in diameter, while the bulbous end was 3 in. wide. It had a mesentery 1 in. long on its proximal portion, but this was difficult to delineate because of the adhesions. It pointed downward and to the left (Fig. 2). Except for extensive adhesions about the anastomosis and in the right lateral gutter, the entire small intestine and the colon were normal. There was no evidence of any malignancy. The diverticulum was excised, and the proximal end of the ileum was inverted and closed at the edge of the stoma. The patient had an uneventful recovery, and he went home on

Fig. 1 (Case 1).—A blind pouch, visible by barium enema, developed in the end of the proximal segment of the ileum, which projected beyond the ileocolostomy.



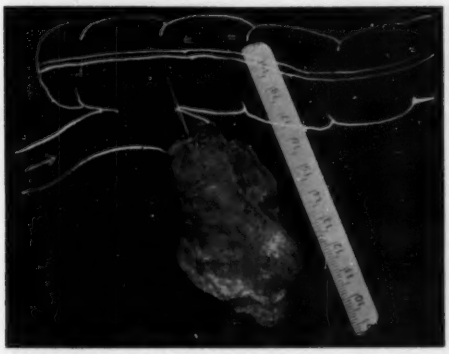


Fig. 2 (Case 1).—The end of the proximal segment of the terminal ileum has enlarged to form a blind sac, measuring 5 in. in length and 3 in. in width. This developed in 15 years from the inverted end, which was left less than an inch long at the time of the ileocolostomy. This composite picture illustrates the position of the blind pouch projecting beyond the anastomosis stoma.

the 10th postoperative day. He has enjoyed good health since then.

Open section of the diverticulum revealed that the mucosa of three-fourths of the blind end was redundant, edematous, and purplish in color. The boggy mucosa presented deep pits and mucosal ulcers. The wall was 0.5 cm. thick at the opening, and at the blind pouch it was 0.2 cm. Sections of the pouch showed active ulcerations, which extended into the submucosa. They were flat, covered by a fibrinoleukocytic membrane, and infiltrated with a variety of inflammatory cells, consisting principally of lymphocytes, plasma cells, and neutrophils. The deeper portion of the submucosa below the ulcers showed moderate fibrosis and numerous hypertrophied nerve fibers. In several sections, the muscularis showed pronounced fibrosis, and it had lost the distinctive quality that one ordinarily sees in the intestine. The serosa was also fibrotic and infiltrated with a moderate number of small mononuclear cells.

Case 2.—A 50-year-old white woman entered the hospital on July 25, 1956. The past history suggested that she had a ruptured appendix in 1945, and this was removed. Obstruction developed a year later, and "an intestinal operation" was performed. In 1954 she had a pelvic abscess with acute intestinal obstruction, which was relieved after more than a pint (500 cc.) of foul pus was drained by cul-de-sac incision. Several more incidents followed, consisting of pelvic induration and pain, associated with mild intestinal obstruction. These were treated with antibiotics. X-ray studies were reported as follows: "The plain plate of the abdomen reveals normal distribution of gas in the colon. Just to the left of the cecum there is an

Fig. 3 (Case 2).—An unusual gas shadow, measuring 2½×1¼ in., lies medial to the cecum. This is due to a large diverticulum in the terminal ileum. The ascending colon is seen to be in its normal position in the plain film of the abdomen.

irregular oval gas shadow, which measures 2½×1¼ in. (Fig. 3).

"Barium enema: The colon fills completely, without any visible pathology. The ileocecal valve is patent, and the barium readily enters the terminal

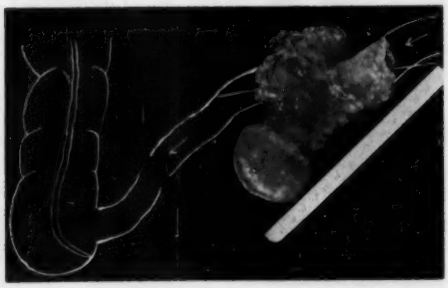
Fig. 4 (Case 2).—A barium enema reveals the widened and elongated intestinal rugae in the blind pouch of the terminal ileum. The position of the pouch corresponds to that of the gas bubble seen in the plain plate of the abdomen (Fig. 3).

ileum. Just medial to the cecum, a short, widened segment of ileum is visible among the intestinal coils. Here, the valvulae conniventes are thickened, and they are 2½ in. long, in an area which is 1 in. wide. Its position corresponds to the large gas bubble seen on the scout film" (Fig. 4).

Hemoglobin 11.4 gm. per 100 cc.; hematocrit 37%; WBC 10,250 per cubic millimeter. She was operated upon on July 28, 1956. The tube and ovary on each side formed a cystic mass, about 3½×2 in. in size, lying behind the uterus. The intestinal loops were densely adherent to each other, especially in the pelvis. Four inches above the cecum there was an old side-to-side anastomosis. The closed end of the distal segment was 2½ in. long and 1 in. in diameter, pointing upward and medially. The distal end of the proximal segment was about 4½ in. long and 2½ in. in diameter, pointing downward and to the right (Fig. 5). This dilated pouch lay between the tubo-ovarian masses. Proximal to the anastomosis the ileum was dilated to twice its normal diameter for a distance of 2 ft. The rest of the intestine and the gallbladder were normal. The mesentery of the pouch was about 2 in. long, while that of the proximal end of the distal segment extended along its whole length.

The involved area was excised, and the continuity of the ileum was restored by an end-to-end anastomosis. Total hysterectomy was performed. The patient had an excellent recovery, and she has remained completely well since then. Open section of the specimen revealed mucosal ulcerations, the largest being 1.5 cm. in length, at the union of the amesenteric sides of the two intestinal segments. Microscopic sections through the ulcers revealed them to extend into the submucosa. Here, there was a heavy cellular infiltration of plasma cells, lymphocytes, eosinophils, and neutrophils. The serosa was thickened by vascularized fibrous tissue, with scattered infiltration by plasma cells and lymphocytes. The adnexa disclosed chronic salpingitis and hydrosalpinx, with tubo-ovarian adhesions.

Fig. 5 (Case 2).—Resected specimen of side-to-side anastomosis in the terminal ileum. The blind end of the proximal segment has enlarged to form a pouch, which is 4½ in. long and 2½ in. wide. The probe is placed in the channel of the ileum through the stoma. This composite picture illustrates the position of the blind pouch 4 in. above the cecum.



Etiology

In side-to-side anastomosis, the circular muscle fibers are divided. This interferes with peristaltic action at the site.[6] This disturbance causes stasis and tends to pack intestinal contents into the blind end of the intestine extending beyond the stoma. Experiments in dogs showed that the blind segment tended to dilate when the direction of peristalsis was from the stoma toward the closed end.[3,4,7,10] The blind end enlarged very little when the segment was made less than 2 ft. in length. Only segments longer than this became dilated within a few months. They contained inspissated intestinal contents and debris. The walls became hypertrophied, and the pouch often perforated.[10] It was found that if the ileocolostomy was done in an isoperistaltic fashion, the distal segment of ileum beyond the stoma was less likely to fill with an accumulation of intestinal contents. Generally, these dogs fared better than the dogs subjected to an antiperistaltic anastomosis. When the peristalses were directed from the occlusion to the stoma, this segment remained undilated and emptied.[10]

The anastomosis performed in the first patient was an isoperistaltic, side-to-side one. The closed end of the proximal segment of ileum was only ¾ in. beyond the stoma; yet in eight years this negligible stump dilated to form a sac 5 in. long and 3 in. in diameter. Pouch formation in man is not necessarily due to leaving in an excessive length of intestine. Perhaps, if many experimental dogs with properly performed lateral anastomoses were to be observed for several years, one might find an occasional pouch developing in the short, proximal, blind end. Other factors must play a part in pouch formation, in addition to the downward direction of peristalsis. Among these are intestinal tone, various neuromuscular changes, such as hypertrophy

of nerve fibers, and positioning of the ends. In the two cases reported, the dilated sacs were directed downward. This is seen in other cases that have been illustrated.[9] It is not known whether the pouch formed because the sac was pointed downward or because it became heavy and turned downward as it enlarged and retained food.

Types of Anastomoses

The technical considerations which are present determine the method of anastomosis to be used after intestinal resection. Some surgeons prefer the side-to-side procedure exclusively. This method should not be condemned and discarded because a blind pouch may possibly form in the proximal segment. It is the easiest one to perform when the mesentery is heavy or fat, and when there is a disparity between the diameters of the segments to be anastomosed. The inverted end of the proximal segment should not project more than an inch beyond the stoma. In ileocolostomy, the length of colon remaining proximal to the opening need not be kept short. This portion will be partly filled by the small-intestine effluence, and it will retain its absorption powers, but it will be emptied by its distally directed peristalsis. There is no stasis or dilatation of this portion.[5]

End-to-side anastomosis is a convenient method, especially for ileocolostomy. Many surgeons employ end-to-end anastomosis whenever it can possibly be used: between segments of the small or large intestine, and in ileocolostomy. The circulation to the antimesenteric border and the caliber of the junction are improved by cutting the open end of the intestine back toward its antimesenteric edge.[8]

When side-to-side anastomosis is used, it should be performed with exclusion and not in continuity. If the patient's condition does not permit a lengthy intestinal resection, simple lateral anastomosis may be made to divert the intestinal contents around the lesion. However, there is the obligation to remove the obstruction at an early opportune time. When the intestine is obstructed by a large and edematous mass, a lateral shunt around the mass may permit the inflammation to subside enough that the segment may be resected at a second operation. It is not wise to leave in a closed loop in continuity, for it will dilate and cause trouble. Various symptoms may follow, such as borborygmi, cramps, diarrhea, anemia, and loss of weight.[4,10] These are eliminated by resection of the closed loop. In regional enteritis involving the terminal ileum, this portion may be excluded and end-to-side ileocolostomy performed. In this disease, the stenosis does not become complete, so that the excluded portion of ileum can empty itself past the lesion.[5] It is not proper to exclude a segment of intestine proximal to a lesion that will progress to complete obstruction. The direction of the peristalsis being from the closed end toward the obstruction, the mucus and gas cannot empty and the closed length will dilate. The closed end may blow out, to cause peritonitis.[4]

Symptoms

The commonest symptoms associated with blind-pouch formation are those of low-grade intestinal obstruction. These are lower abdominal colicky pain of varying intensity, distention, borborygmi, and vomiting.[1,4,6] The obstruction may be caused by the distention and weight of the sac, which may pull upon, twist, or kink the intestine. Inflammation around the lesion may cause obstruction by adhesions and by compression. Some have diarrhea, anemia, and nutritional changes.[2,6,5] Ulceration of the mucosa and elongation of the blind segment are causes of these symptoms. A foreign body, such as a bone, may lodge in the sac and cause symptoms.[6] The only indication of a large pouch may be a palpable, sausage-shaped mass.[5] A 16-year-old boy, following a lateral ileocolostomy, developed in one year loss of weight, diarrhea, and distention. The lower two-thirds of his abdomen became filled with the dilated and hugely elongated blind segment of the terminal ileum. This

measured 18 in. in length and 3 to 4 in. in diameter and had undergone marked ulceration.[4] In children, the increase in size of the pouch is greater than can be attributed to the normal growth of the intestine. In a 14-year-old girl, nine years after partial colectomy with side-to-side ileocolostomy, x-ray studies showed that the asymptomatic pouch had increased from 14 to 22 cm. in length in five years and from 3 to 4 cm. in width.[11] In the first case reported here, the size of the pouch had not changed in five years, as determined by barium enema examination. The patient's only symptom of this lesion was a huge hemorrhage, due to one of its ulcers. The second patient's pelvic abscess may have been due to perforation of the blind pouch, but it may have resulted from the disease of the adnexa. On the other hand, asymptomatic, small, blind pouches are sometimes seen when the abdomen is opened later in patients who have had a lateral anastomosis. This was often observed at the second stage of a two-stage intestinal resection.[1]

Diagnosis

Roentgen studies are the most valuable aid in preoperative diagnosis of blind-pouch formation. A large gas bubble may be visible on a plain plate of the abdomen, as was seen in the second patient. The diverticulum may be recognized by the barium in it, or by the presence of elongated and hypertrophied intestinal rugae in a localized area.

When a patient has abdominal complaints or anemia, and it is known that he has had an abdominal operation, the surgeon may consider the possibility of blind pouch or blind intestinal loop. The only pathognomonic sign, which may be present, is a palpable, soft mass in the abdomen. There may be various indications of obstruction, with distention and borborygmi.

Comment

A blind pouch may develop in the closed end of the proximal segment following side-to-side anastomosis. This does not occur with the other methods of joining intestinal segments.

The enlarged sac is not necessarily dependent upon leaving in a long, blind end in the proximal segment projecting beyond the stoma. An end no longer than an inch developed into a large diverticulum in the first case reported.

Experimentally, in dogs, a symptomatic, blind pouch will develop only if the segment left behind is made longer than 2 ft.

The usual symptoms are abdominal cramps, borborygmi, distention, vomiting, diarrhea, and anemia. A palpable mass may be present. In one case reported the only symptom was a massive intestinal hemorrhage. A large pelvic abscess seems to have been the only symptom in the second patient.

X-ray studies are the most important means of preoperative diagnosis. A large gas bubble may be seen on the plain plate. Barium may be retained in the diverticulum. Elongated and hypertrophied mucosal folds of the pouch may be recognized.

Resection of the blind pouch will abolish the symptoms.

There are infrequent reports of clinically significant pouches developing after lateral anastomosis. One may grow even when proper surgical technique is used. While end-to-end anastomosis should be performed whenever possible, the technique of lateral anastomosis should not be condemned and discarded.

When a patient has abdominal complaints, and it is known that he has had an intestinal operation, the surgeon must consider that a lateral anastomosis may have been performed. A blind pouch may have developed to cause these symptoms.

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An Evaluation of the Hazards of Aortography

ERIC SAMUEL, M.D., and MICHAEL DENNY, M.B., Ch.B., Johannesburg, South Africa

Conger et al.[1] recently reported a fatal case of renal failure following translumbar aortography. Hare[2] also recorded a fatal case following such a diagnostic procedure, and Goodwin, in an editorial comment[3] on Conger's report, discussed some of the hazards of this procedure.

In view of the work of Gaylis and Laws[4] and in the light of our own experiences, it appears that some of the contentions made by Conger et al. are untenable, and it would seen unwise to allow the erroneous impressions likely to be created by their article to go unchallenged.

There are two aspects of Conger's reported case which deserve scrutiny: (*a*) the actual mechanism of renal failure, and (*b*) the technique of the examination—translumbar aortography.

A. Mechanism of Renal Failure

The authors have cited two possible causes of the renal failure: first, a chemotoxic effect due to an overdose of contrast medium, and, second, a sensitization reaction to "iodine compounds."

In our opinion the probable cause of renal failure in the authors' case, however, has been overlooked. It requires but a cursory glance at *A* and *B* of Figure 1 to note the presence of an aortic dissection phenomenon (Gaylis and Laws[4]). The features indicating that this has occurred are clearly shown in the illustrations and are as follows:

1. In Figure 1*A* the needle point has entered the opposite side of the aorta, and the intramural deposit of dye, with commencing dissection, cannot be ignored. It is clear that the initial exposure was probably taken after the administration of some 15 cc. of 70% sodium acetriozoate, i. e., prior to completion of the injection. The registration on the radiograph of the lower limit of the dissection is thus momentary, and it is probable that immediately after the exposure dissection extended rapidly in a caudal direction.

2. The direct consequence is equally clearly defined. Not only have both orifices of the renal arteries been occluded but the point of origin of the superior mesenteric artery has also been obliterated. The reasons for this latter statement are as follows:

(*a*) The presence of contrast medium at the site of puncture and in the peripheral branches of the superior mesenteric artery in the film exposed 10 minutes later. This most certainly represents a gross delay in diffusion of the dye.

(*b*) The presence in the 10-minute film of a nephrogram of only slightly greater density than that showing in the arterial phase, when normally at this time the nephrogram phase should have disappeared, to be replaced by an excretory pyelogram.

(*c*) The presence of what in the illustrations appears to be dye following the course of a second-order intrarenal branch of the left renal artery inferiorly. This may possibly represent a dissection along the renal artery itself.

Dissection of the aorta and of the mesenteric and renal arteries, we believe, is not an infrequent occurrence with the translumbar aortographic method. This dissection is of varying degree and is not inevitably followed by any appreciable ill effects.

Figures 1 to 4 of this communication illustrate a case of unquestionable aorta dissection with extension first along the renal artery, finally resulting in a renal subcapsular dissection. No ill effects were

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Fig. 1.—Translumbar aortogram, showing extensive intramural dissection of the aorta and an extremely dense shadow of the left kidney. Contrast medium is present in the right kidney, but some dye is present in the superior mesenteric artery.

Fig. 2.—Ten-minute film demonstrating persistence of the dye in the left kidney, some extravasation of dye, and an intramural dissection in the aorta.

experienced by the patient, and a subsequent aortogram revealed a normal pyelogram on each side.

The chemotoxic effect of contrast media has been proved experimentally, but its occurrence in clinical practice is still *sub judice*. In our studies of over 100 aortographic cases no ill effects on kidney function have been demonstrated. These investigations have included eight cases of the Leriche syndrome in which a high concentration of contrast medium (76%) entered the renal arteries. Furthermore, we feel that the use of triiodo compounds, in the nature of Urografin (a mixture of sodium and methylglucosamine salts of 3-5-diacetylamino-2,4,6-triiodobenzoic acid) and diatrizoate (Hypaque), would lessen the possibility of a chemotoxic reaction, presuming that this is a clinical entity.

Fig. 3.—Twenty minutes after the injection, showing dye still remaining in the left kidney and an early pyelogram of the right kidney.

Fig. 4.—Seven and one-half hours after the injection, demonstrating a persistence of the dye in the subcapsular portion of the left kidney.

We personally have had only a small experience with diatrizoate in either intravenous pyelography or cerebral angiography, but we have used Urografin for close on three years for all vascular examinations, and the one fatal reaction which occurred has not been related to the dye used. In this case thrombosis of a middle cerebral artery followed catheterization of the common carotid artery for the purpose of delineating a mediastinal tumor. The ill effects were observed to follow a 5 cc. test dose, given to determine the position of the catheter tip. Whether the contrast medium or the instrumentation in this case is to be incriminated remains a matter of speculation.

We agree with Conger that sensitization to the iodine compound can hardly be considered in his case, as sensitization reactions of this nature are not common, and it should be made clear that such reactions are related to the particular compounds and not to the bound iodine molecules. We have observed only one reaction which could be considered as a sensitization reaction. This appeared as a marked chemosis following the instillation of a drop of contrast medium into the conjunctiva.

B. The Method of Aortography

It has long been known that a variety of complications can follow the translumbar method. In addition to renal failure, paraplegia, chylothorax, hemothorax, embolization, intestinal ileus, acute pancreatitis, and mesenteric thrombosis are all known to have occurred.

We have been aware of the dangers, though admittedly uncommon, of translumbar aortography, and consequently were eager applicants of the unique method of catheter replacement so competently devised and described by Seldinger.[5] Since using this method, we have never ceased to be amazed by the absence of reports on its use in the American literature. There is no doubt that the advance of this technique has greatly increased the scope of arteriography. It has furthermore, we believe, eliminated the majority of dangers attendant on translumbar aortography, and the technique is as easily accomplished.

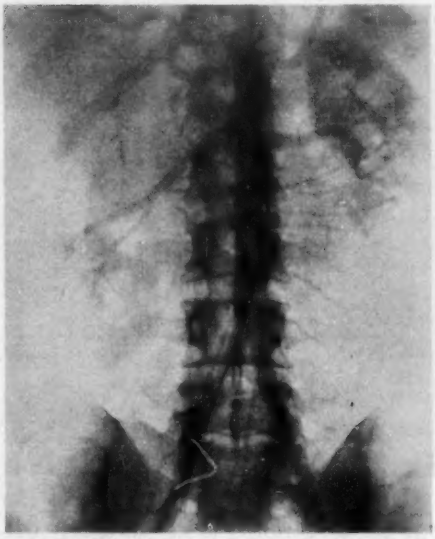

Fig. 5.—Seldinger technique, demonstrating the catheter in position and filling of the renal vessels.

For a detailed description the reader is referred to the original and subsequent papers by Seldinger. Briefly, the catheter is ultimately introduced into the artery over a flexible guide wire which has previously been passed, through a percutaneously inserted cannula, into the artery. The wire is withdrawn and the catheter inserted to the desired level.

With regard, then, to the problem of abdominal aortography, the method may be evaluated as follows:

(*a*) In the study of cases of peripheral vascular disease the Seldinger catheter can be passed well below the level of the renal arteries, thus sparing the kidneys the effect of the concentrated contrast medium.

(*b*) The possibility of extravasation and, more important, dissection, probably the basic cause of all major complications following translumbar aortography, disappears.

(*c*) In the study of renal diseases, in which, contrary to Conger et al.,[1] we believe aortography plays an important part,

the ultimate value of which has not yet been fully developed, the catheter can be placed accurately above the renal arteries. This avoids direct injection of the contrast medium into or at the level of the renal arteries, an important factor if one is to accept the chemotoxic theory. On the other hand, accurate positioning of the catheter at the renal artery orifice permits of the use of smaller amounts of contrast medium (12 cc.) while producing an adequate renal arteriogram and nephrogram.

(*d*) The Seldinger method, even in young people, rarely requires a general anesthetic and is performed with the patient in the more comfortable supine position. This method is used by us in all cases of peripheral vascular disease where patent femoral vessels are present. Translumbar aortography is reserved for the rare failures—three in our series—and the Leriche syndrome. We have had no instances of embolization in our series. Fernström,[6] with about 700 catheterizations in 448 patients, has had no noteworthy complications. For renal angiography we use the Seldinger method exclusively. It would appear that debate on the value of translumbar aortography in respect to renal disease is consequently outmoded and redundant. The method is plainly and simply contraindicated. This is particularly so in the investigation of the renal blood supply in hypertensive disease. We have, while investigating cases of this nature, been surprised at the duration and extent of pressure needed to stop oozing from the puncture site in the hypertensive patients. In such a case, the inaccessible aorta bleeds freely, and in cases of hypertension this could conceivably have proved fatal. We have, in fact, observed on serial radiography the spread of a massive retroperitoneal hematoma in one such case following a translumbar puncture, fortunately without fatal result.

Summary

Attention is drawn to aortic dissection as the most likely causative factor in a case of renal failure discussed in a paper of Conger et al. The chemotoxic theory of renal failure is discussed and is considered not to be yet proved.

Attention is drawn to the method of arteriography devised by Seldinger, with particular reference to abdominal aortography.

Contrary to the opinions of Conger et al., we consider that arteriography in renal diseases is of value and that its full importance is still to be realized.

We, furthermore, consider that translumbar aortography is contraindicated in renal diseases and that a greater and more general use should be made of Seldinger's method in both abdominal aortography and peripheral vascular disease.

Mr. Max Lautre and Dr. Harris Jackson permitted use of Figures 1 to 4.

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Foreword

At a recent meeting of the staff of the U. S. Naval Hospital, Yokosuka, Japan, 12 Navy consultants presented a group of medical papers. At this meeting, too, Professor Nakayama, of Chiba University (Japan), and Dr. Yoshioka, of Tokyo University, discussed radical gastrectomy for carcinoma and transabdominal neurotomy for pancreatitis, respectively, and presented colored motion pictures to illustrate their techniques.

Although Dr. Yoshioka has published his paper in the Japanese medical journal *Shizitsu*, and a copy of it is to be published in *Lyon chirurgical* (Prof. Pierre Mallet-Guy, Editor), it seemed to be of sufficient interest to English-reading surgeons to warrant its publication also in the A. M. A. ARCHIVES OF SURGERY. This paper has been reviewed by a prominent American neurosurgeon and by an American physician who is a professor of anatomy. They also reviewed the motion picture of the operative technique employed which is described in the paper. Both of them believe that the method is an acceptable anatomicosurgical procedure. The originality of the technique is indicated by the anatomist, who said: "I wasn't aware that the chief innervation of the pancreas reached it through pedicles as described in this paper, but a check makes it seem probable."

WALTMAN WALTERS, M.D.

Therapeutic Neurotomy on Head of Pancreas for Relief of Pain Due to Chronic Pancreatitis

A New Technical Procedure and Its Results

HAJIME YOSHIOKA, M.D., and TOSHISHIGE WAKABAYASHI, M.D., Tokyo

Introduction

Mallet-Guy and his co-workers [1,2] performed, in 1942, left unilateral splanchnicectomy in a case of chronic relapsing pancreatitis for the first time in the world. He has now come to the opinion, from clinical and experimental studies, that the operation is not only a palliative procedure for interruption of the pain pathway from the pancreas but a radical curative measure by *rompant l'arc reflexe par section des fibres centrifuges.*[2] Following him, various reports have been made on operations on the autonomic nervous system for this purpose, e. g., splanchnicectomy (Fontaine et al.[6]), sympathectomy (Smithwick [7]; de Takats [8,9]), celiac ganglionectomy (Grimson [10]), and vagectomy combined with sympathectomy (Rienhoff [11]). The excision of autonomic nerve fibers in any of these locations might more or less relieve pancreatic pain, since the nerves sectioned contain visceral afferent sensory fibers as well as visceral efferent motor fibers. But further inquiry should be made on the rationality

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From the Department of Surgery, Tokyo Metropolitan Police Hospital.

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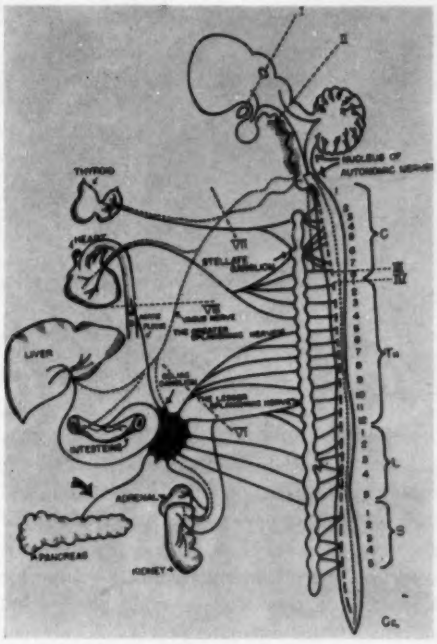
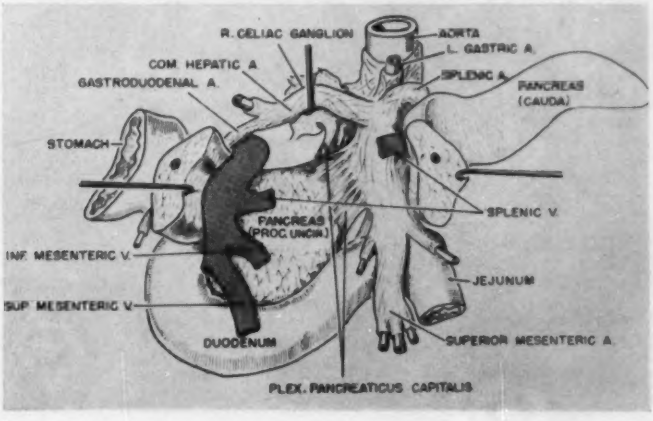


Figure 1

of these operations from the anatomical point of view.

Most, if not all, of the autonomic nerve fibers which innervate the abdominal viscera pass through the bilateral celiac ganglia (Fig. 1). There are four types of autonomic nerves running into the celiac ganglia, namely (1) the greater and lesser splanchnic nerves, (2) many filaments which come from the lower portions of the thoracic sympathetic chains and the upper portions of the lumbar sympathetic chains, (3) many branches from the plexus which surround the aorta, and, finally, (4) the right vagus nerve. Therefore excision only of the splanchnic nerve or of the thoracic sympathetic chains or even of both does not interrupt the branches from the aortic plexus, the lumbar sympathetic chains, and the vagus nerve; in other words, the above-mentioned operations are not very satisfactory. On the other hand, excision of the preganglionic fibers will interrupt not only the innervation of the pancreas but, at the same time, those supplying all the abdominal organs, leaving some side-effects. Celiac ganglionectomy might deprive all abdominal organs completely of their autonomic innervation. What we are really aiming at is the interruption of the sensory pathway and reflex arc only from and to the pancreas, leaving other organs intact. For this purpose the section of the post-ganglionic fibers just before they reach the pancreatic substance must be the method of choice. But can this really be done?

Fig. 2.—Anterior view of plexus pancreaticus capitalis. The body and tail of the pancreas are removed, exposing the uncinate process, the superior mesenteric artery and vein, and the plexus.



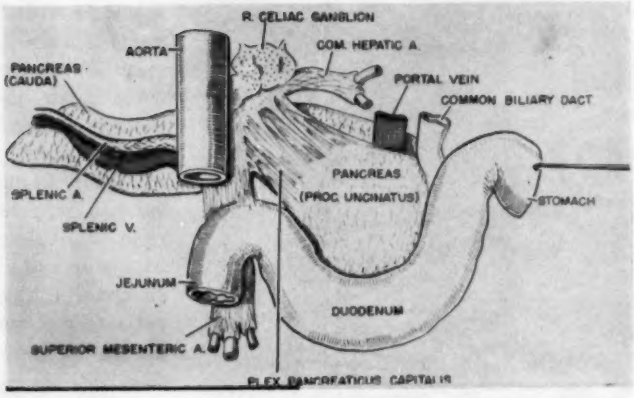


Fig. 3.—Posterior view of plexus pancreaticus capitalis.

Anatomy of "Plexus Pancreaticus Capitalis"

In 1950 we studied the anatomical relationship of the postganglionic fibers from the celiac ganglia to the pancreas on 100 cadavers in the Institute of Anatomy of Professor Fujita, of Tokyo University Medical School. We drew the following conclusion: The majority of the postganglionic fibers from both celiac ganglia join together, becoming a large bundle accessible for section, and enter the medial margin of the uncinate process of the pancreas (Figs. 2 and 3). This structure we called the "plexus pancreaticus capitalis." Figure 4 shows the plexus more plainly. This plexus can be divided into two portions, as illustrated schematically in Figure 5. The first portion of the plexus consists of fibers running from the right celiac ganglion and entering the upper medial margin of the uncinate process. The second portion consists of fibers coming from the superior mesenteric artery and entering the medial margin of the uncinate process. Therefore the latter contains fibers passing through both celiac ganglia and fibers coming from the aortic plexus.

Naturally, this plexus does not contain all of the autonomic nerve fibers which innervate the pancreas. Some fibers may enter the pancreas accompanying the blood vessels, particularly the splenic, and superior and inferior pancreaticoduodenal arteries. As a

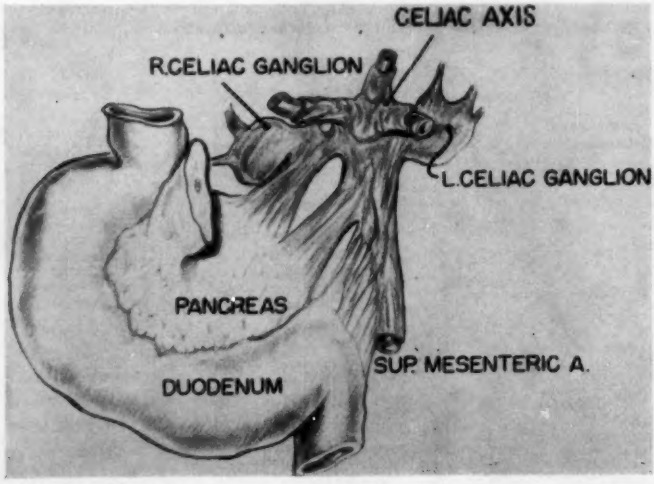


Fig. 4.—Anterior view of plexus pancreaticus capitalis.

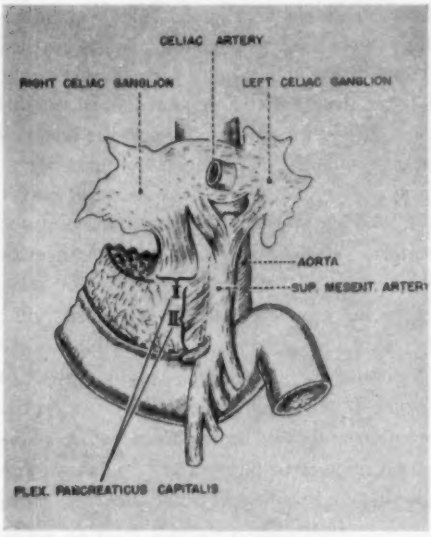


Fig. 5.—The first and second portions of the plexus are schematically illustrated.

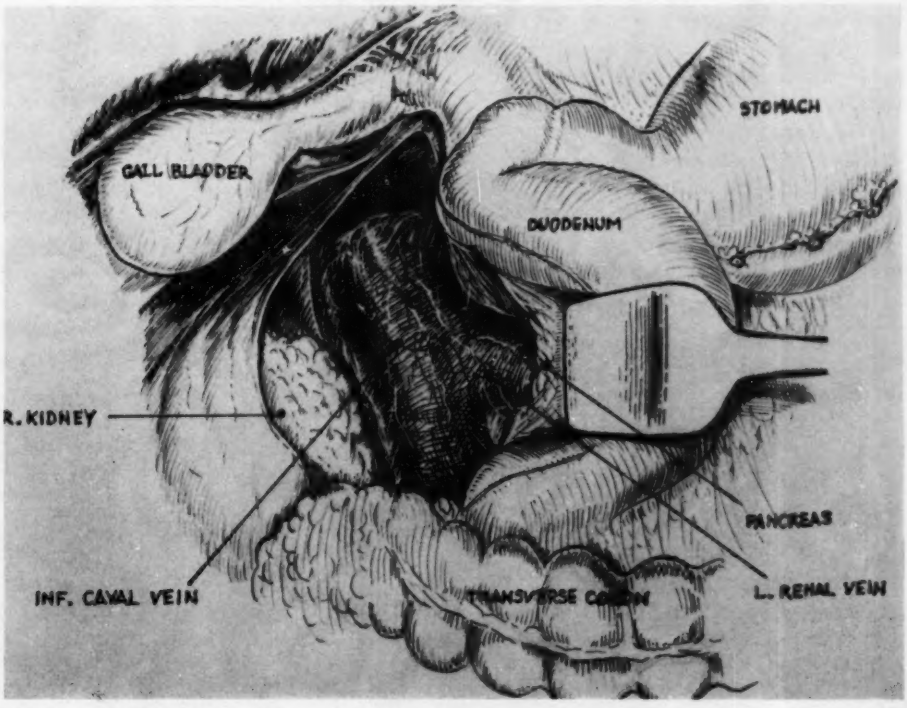
matter of fact, this plexus contains the majority of the autonomic nerve fibers which innervate the pancreas, and clinically excellent results have been obtained by the section of this plexus. We will now explain the technical procedure.

Technical Procedure

Körte's right upper paramedian and oblique paracostal incision is the best approach by which to reach the plexus. Both portions of the plexus have to be divided.

1. *Section of the First Portion.*—Since the first portion of the pancreatic plexus lies behind the uncinate process, the posterior approach, by elevating the duodenum and the head of the pancreas, is most convenient for its section. The uncinate process is freed as well as possible from the posterior abdominal wall, with gauze, the entire head of the pancreas being rotated to the left by

Fig. 6.—The peritoneum is incised along the second portion of the duodenum, and the duodenum, together with the head of the pancreas, is retracted to the left.



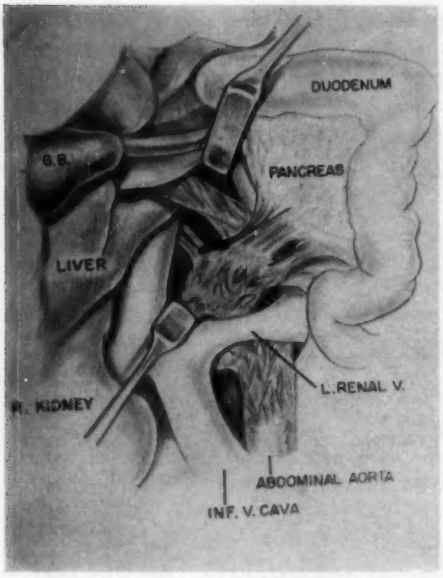
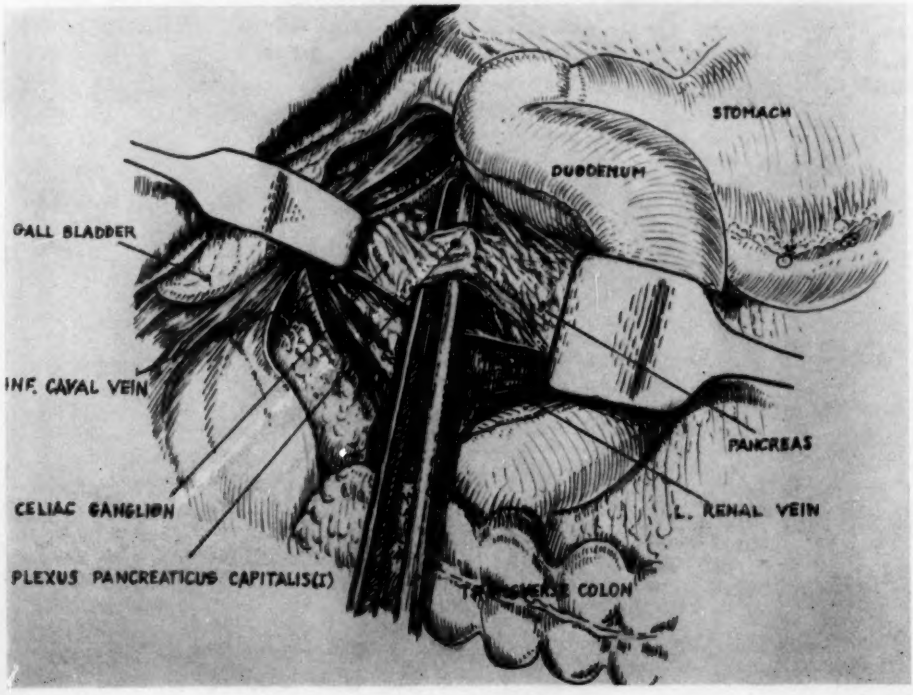


Fig. 7.—The right celiac ganglion and the first portion of the plexus are shown.

Kocher's method (Fig. 6). This mobilization is very easy to do, but a point is reached where further liberation becomes impossible. This is the point where the plexus extends from the right celiac ganglion to the uncinate process and the superior mesenteric artery (Fig. 7). The superior mesenteric artery can be identified by its pulsation. On the posterior wall of the abdomen the inferior vena cava and both renal veins can be seen. In the angle where the left renal vein joins the inferior vena cava the right celiac ganglion can be found, as illustrated in Figure 7. A lymph node usually lies on the ganglion and may be mistaken for it. This lymph node is to be removed. Then a large fan-shaped bundle of nerve fibers is seen running from the ganglion to the upper medial margin of the uncinate process. Forceps are applied, and the bundle is divided (Fig. 8).

Fig. 8.—The first portion of the plexus is freed upward and then sectioned.



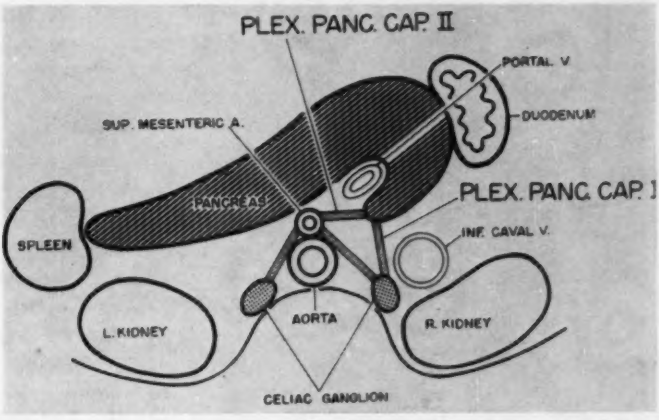


Figure 9

2. *Section of the Second Portion.*—This can be performed either by the posterior or the anterior approach. (*a*) Posterior Approach: The uncinate process receives a board-like bundle of nerve fibers from the superior mesenteric artery extending over the entire length of its medial margin (Figs. 5 and 9). This is the second portion of the plexus. After section of the first portion, the second portion can easily be seen, and this must be carefully divided, little by little, between clamps, because it usually contains some arterial branches. Care must be taken not to cut the nerve fibers running from the right celiac ganglion to the superior mesenteric artery (Fig. 9), lest diarrhea result as a side-effect of loss of the sympathetic innervation of the intestine. For this purpose attention must be paid to dividing the nerve fibers between the superior mesenteric artery and the medial margin of the uncinate process, identifying the superior mesenteric artery by its pulsation.

(*b*) Anterior Approach: The gastrocolic omentum is divided, and the lesser omental sac is entered. The transverse colon is pulled downward and the stomach upward. The peritoneum is incised along the inferior border of the pancreatic neck and body (Fig. 10), and the pancreas is lifted up, exposing the superior mesenteric artery and vein (Fig. 11). The superior mesenteric artery must be carefully palpated and identified. When the superior mesenteric vein is displaced to the right, the medial border of the uncinate process will come into view (Fig. 12). The bridge of nerve fibers between the superior mesenteric artery and the

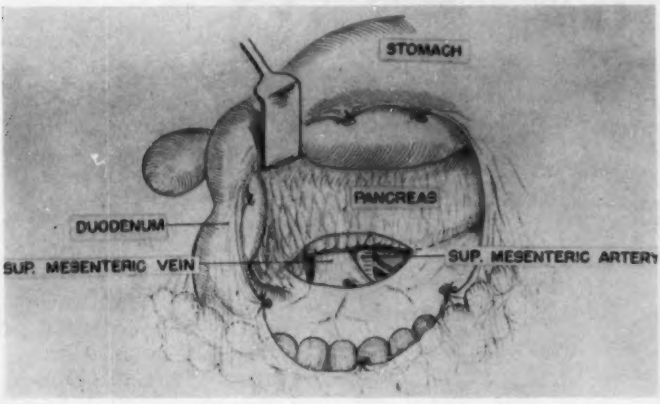


Fig. 10.—The peritoneum is incised along the inferior border of the pancreas.

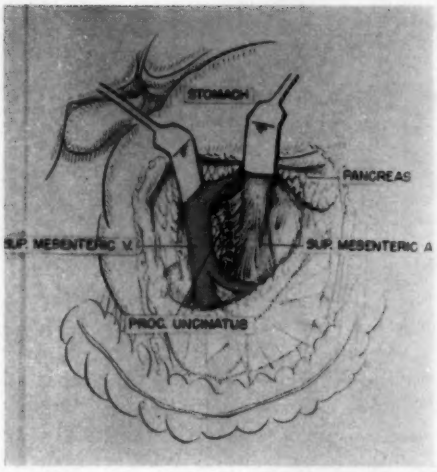


Fig. 11.—The neck and the body of the pancreas are lifted up, exposing the superior mesenteric artery and vein.

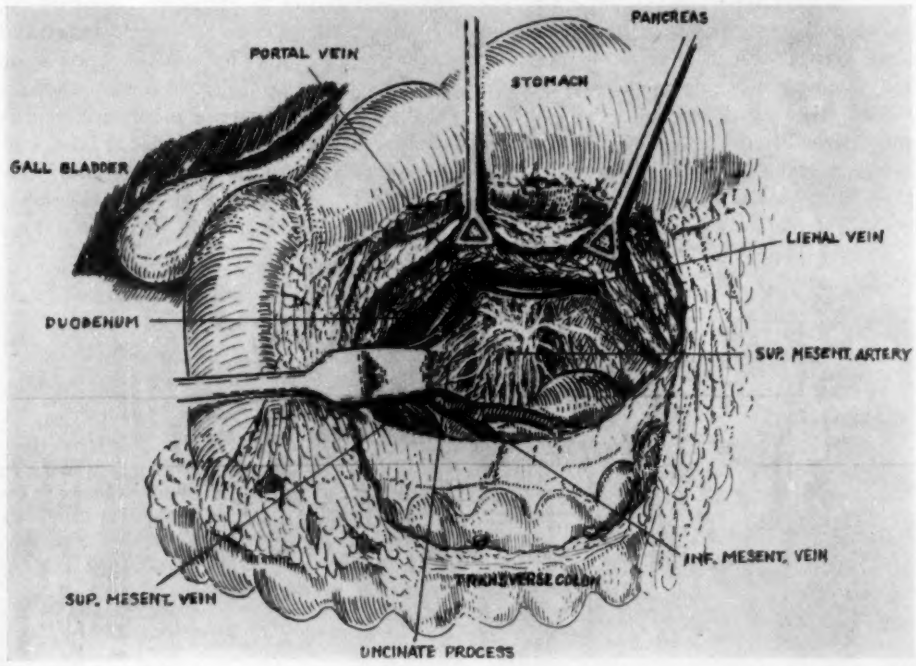
uncinate process is then divided little by little between clamps (Fig. 13). The inferior pancreaticoduodenal artery is also severed and ligated.

Selection of either the anterior or the posterior approach is made according to convenience in the individual case.

Results

Of 75 patients operated on during the period of 1952 to 1957, chronic pancreatitis only was present in 36; in addition to the pancreatitis, 2 had cancer of the pancreas, 19 biliary dyskinesia, and 18 gallstones and cholecystitis (Table). As biliary dyskinesia, however, we preferred only cases of sphincteric hypotonicity confirmed by radiomanometry. In patients with chronic pancreatitis and biliary dyskinesia the results were always excellent and satisfactory. But in two cases of chronic pancreatitis abscesses were found in the tail of the pancreas, and therefore the left half of the gland was resected at the same time. In the cases of cancer of the pancreas the effect was transient. In the case of gallstones and cholecystitis, additional cholecystectomy and removal

Fig. 12.—The superior mesenteric vein is retracted to the right, exposing the uncinate process.



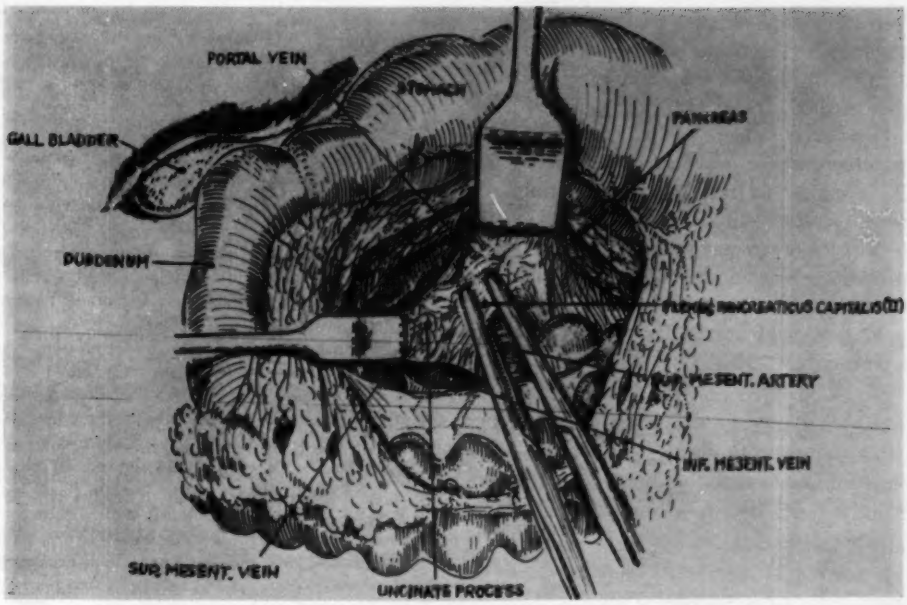


Fig. 13.—The second portion of the plexus is sectioned, little by little, between two clamps.

Diagnosis in Seventy-Five Cases of Chronic Pancreatitis

Diagnosis	No. of Cases	Results
Chronic pancreatitis	36	35 excellent 1 died of shock
Biliary dyskinesia	19	All excellent
Cholecystitis and gallstones	18	Excellent (but cholecystectomy and removal of stones combined)
Cancer of pancreas	2	Effect transient
	75	

of stones from the common bile duct were performed, and the results were excellent. As far as the mortality due to the surgery is concerned, one patient died of shock shortly after the plexus was transected. Here we must add that the blood pressure level always falls suddenly immediately after the section of the plexus. As to the side-effects of the operation, the one and only complication which occurred frequently was diarrhea. This occurred in cases in which the fibers running from the celiac ganglion to the superior mesenteric artery were erroneously divided. Therefore we must emphasize again the care necessary in this section. The diarrhea may be due to deprivation of sympathetic innervation of the intestine. Disturbances of carbohydrate metabolism and external secretion could not be demonstrated. In 35 cases of chronic pancreatitis no recurrence of pain attacks was noted to date.

Comment

Since Mallet-Guy performed left splanchnicectomy in the treatment of chronic relapsing pancreatitis in 1942, various procedures of neurotomy have been presented for this purpose, e. g., unilateral and bilateral sympathectomy, celiac ganglionectomy, and vagectomy. But, theoretically, to section the nerve fibers after leaving the celiac ganglion just before they reach the pancreas is considered a better method, since with this operative procedure all the autonomic nerve fibers, including the fibers from the aortic plexus, may be sectioned and the autonomic innervation of the other abdominal organs can be preserved. We studied the anatomical relationship of the nerve plexus from the celiac ganglia to the pancreas and devised a new technical procedure for this purpose.

We called the plexus "plexus pancreaticus capitalis." The fibers which enter the gland along with the splenic artery are not cut by this method. However, if it is desired, the splenic artery can be easily cut, or additional *pancreatectomie gauche* can be carried out. As a matter of fact, we have obtained excellent results only with the section of the plexus pancreaticus capitalis. Moreover, this procedure has another advantage, that this operation can be performed in the same operating field at the time of exploratory laparotomy.

At the present time this operation may be considered the one of choice for the relief from pain due to chronic pancreatitis. But it is advisable that the anatomical relationship be carefully studied on cadavers before attempting this operation.

Summary

Our new technical procedure for the relief of chronic relapsing pancreatitis is outlined. We have treated 75 cases with this intervention and obtained excellent results.

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Epiploic Appendages as a Cause of Intestinal Obstruction

Report of Two Cases

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The epiploic appendages are rarely the cause of intra-abdominal disease necessitating surgical intervention. Even less common is the occurrence of mechanical intestinal obstruction on the basis of disease involving them. In a recent study, Lynn et al.[1] found 156 reported cases, of which 13 presented with intestinal obstruction. They further reviewed the records of the Mayo Clinic for a 13-year period (1940-1953) and found 17 cases of symptoms resulting from disease involving these appendages. Of these 17 cases, only 2 presented with intestinal obstruction. In the past two years, two cases of mechanical bowel obstruction on the basis of epiploic appendagitis have been diagnosed and surgically corrected in the Memorial Hospital, Hollywood, Fla. The following case histories will reveal that both these patients presented with classical signs and symptoms of mechanical bowel obstruction. Each presented x-ray evidence of an obstructive lesion of the large bowel. Both these cases were subjected to laparotomy for large-bowel obstruction, and the diagnosis was substantiated by this means in both instances.

Report of Cases

CASE 1.—*History.*—This 62-year-old white woman was admitted on Sept. 7, 1956, in the evening with the following complaints. Approximately five days prior to admission the patient noted the onset of abdominal pain and nausea without any vomiting. She also noted slight abdominal distention and the absence of any bowel movements. She consulted her family physician, who advised admission to the hospital, with an admitting diagnosis of probable intestinal obstruction. The past history was significant in that this patient had undergone an operation in Pasadena, Calif., approximately four years prior to this admission, at which time she was told that "a portion of bowel had been removed because of a tumor." Since that operation the patient had done exceedingly well, maintaining her weight and general nutrition in excellent state.

The family history and systemic review were within normal limits. The social history was significant in that the patient was a Christian Scientist.

Physical Examination.—On admission the blood pressure was 132/84 in the right arm, reclining. The temperature was 99 F; the pulse 95 and the respirations 20 per minute. The patient was seen to be well nourished and well developed. She was in moderate distress, with cramping lower abdominal pain and slight distention of the abdomen. The significant physical findings were limited to the abdomen. There was noted to be slight distention and rather generalized abdominal tenderness, which seemed most marked in the left lower quadrant. Bowel sounds were infrequent, but occasional high-pitched tinkles were audible in the lower quadrants. There was a well-healed right-lower-quadrant, transverse incision. Rectal examination was normal. The diagnostic impression at the time of this initial examination was partial mechanical large-bowel obstruction. Postoperative adhesions or recurrent neoplasm with extrinsic bowel obstruction was considered as a possible etiologic factor.

Laboratory Data and Clinical Course.—Urinalysis on admission revealed a trace of albumin, a 2+ reaction for sugar, and a strongly positive response for acetone. White cells were seen occasionally. The blood count on admission showed 15 gm. of hemoglobin per 100 cc. and 5,300,000 red cells and 7250 white cells, per cubic millimeter. Determination of fasting blood sugar the following day revealed a level of 110 mg. per 100 cc. A flat plate of the abdomen revealed the presence of moderate gaseous dilatation of the large bowel, with some loops of terminal ileum also containing

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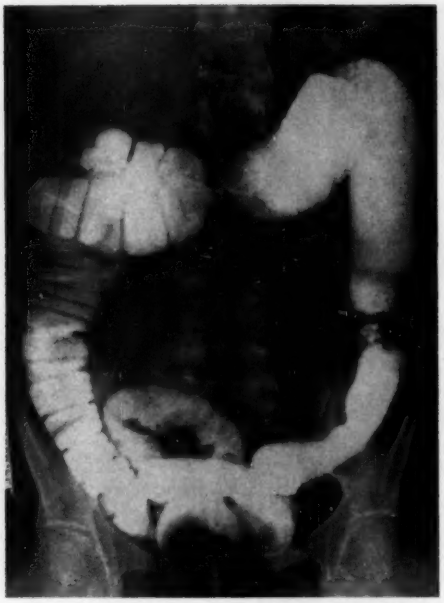

Fig. 1 (Case 1).—Circumferential constricting lesion in the descending colon. This area persisted on multiple views and resulted from an overlapping epiploic appendage.

gas. Fluid levels were present on the film in the erect position. There were no abdominal masses discernible. A small area of discrete calcifications was present in the right pelvic area and was thought to represent calcified uterine leiomyomata. A chest film was normal. A barium enema study was then carried out as an emergency procedure, utilizing a thin barium mixture. The colon was observed to fill to the level of the midpelvic portion at the crest of the ileum. Here, a well-defined, intrusional type of obstruction was noted (Fig. 1). This was interpreted as a partial mechanical obstruction at the level described, the probability being that this represented an extrinsic lesion, since the mucosal pattern appeared normal. The barium enema was repeated in three days. At this time the large bowel filled completely, and the previously noted constriction in the midsigmoid colon persisted but did not appear as marked as when originally seen. This study also revealed evidence of an anastomosis between the transverse colon and the small bowel, probably ileum. It was the opinion of the radiologist that this represented an extrinsic obstructive type of lesion, since the mucosal pattern appeared normal.

Therapy.—The patient was begun on nasogastric suction, antibiotics, intravenous fluids, and electrolytes, and nothing by mouth. She was seen to improve somewhat on this regime. The tenderness in the left lower quadrant persisted, and, in view of the clinical course and x-ray findings, operation was advised. On Sept. 13 the patient was operated upon under general inhalation cyclopropane anesthesia. A left-lower-quadrant, transverse incision was made, and the peritoneal cavity was entered. There was seen to be a previous anastomosis of the end of the ileum to the side of the transverse colon, which had a very adequate stoma and showed no evidence of obstruction. Examination of the pelvis disclosed the uterus to be small, with two subserosal leiomyomata. The larger leiomyoma was posterior in position, measuring approximately 1.5×1 cm. in diameter. The ovaries and tubes were normal to palpation. The sigmoid colon was seen to be the site of a constricting, inflammatory process. On closer inspection there was seen to be an overlapping, hemorrhagic, infarcted epiploic appendage, which had overlapped the sigmoid colon in its midportion and was adherent to the left lateral pelvic wall. During the inspection of this area, this appendage was inadvertently torn loose from its inflammatory attachment to the left pelvic wall. This allowed release of the obstruction, and the colon was immediately seen to balloon out in this area to approximately 80% of its normal size. One could easily pass a thumb through the previously constricted area. The wall and mesocolon were somewhat edematous, but these changes were interpreted as being purely inflammatory, since there were no other evidences of a neoplastic process. The infarcted epiploic appendage was then excised, after suture ligation of the base. The wound was then closed in layers, utilizing No. 32 stainless-steel wire sutures. The patient tolerated this procedure well and was returned to the recovery unit in good condition.

Diagnosis.—The postoperative diagnosis was partial mechanical large-bowel obstruction due to an infarcted epiploic appendage in the midsigmoid. The pathology report was a hemorrhagic tag of adipose tissue measuring 3×2×1 cm.

The microscopic report follows. "This is an epiploic fat tag which has sustained a great deal of hemorrhage. It is not, however, gangrenous, but it is acutely inflamed."

Subsequent Course.—The postoperative course was completely uneventful. The patient was maintained on nasogastric suction for two days, after which the tube was removed, when bowel sounds were audible. The patient was discharged on Sept. 18, on the fifth postoperative day.

Follow-up examinations on an outpatient basis revealed the patient to be doing well. Her bowels were moving regularly. The wound was healed nicely, and she had no further complaints.

CASE 2.—*History.*—This 66-year-old white man was admitted to the hospital on Aug. 24, 1955,

complaining of pain in the right flank, of two days' duration, radiating to the right testis. The pain was constant and moderately severe and was accompanied by two episodes of nausea and vomiting. There were additional complaints of urgency and frequency in urination.

Five years previously, after a similar episode, the patient was told he had a stone in the right kidney. The remainder of the history and the systemic review were noncontributory.

Physical Examination.—The physical examination on admission revealed an obese white man, complaining of pain in his right flank and right testis. The pulse and temperature were normal, and the blood pressure was 150/90 (right arm reclining). The significant findings were limited to the right abdomen and flank. There was tenderness in the right costovertebral angle and along the course of the right ureter.

Laboratory Data and Clinical Course.—The blood count was normal.

Urinalysis showed the presence of numerous red blood cells, although no gross hematuria was evident. The urology service ordered intravenous pyelograms, which revealed chronic pyelonephritis on the right side without evidence of calculi.

Forty-eight hours following admission to the hospital the patient's abdomen became distended. This symptom was interpreted by the urologist as paralytic ileus secondary to the genitourinary disease. Surgical consultation was obtained. Examination at this time revealed generalized abdominal distention and tympany. No bowel sounds were audible, and there was some tenderness along the course of the descending and sigmoid colon. The possibility of mechanical bowel obstruction was considered by the surgical consultant, and intubation was accordingly carried out, using a Miller-Abbott tube. The fluid-electrolyte balance was corrected by appropriate repair solutions.

X-rays of the abdomen showed "moderate distention of the entire colon and part of the small bowel."

The patient was treated conservatively for 24 hours. At the end of this period a barium enema study was performed and disclosed a constricting defect of the pelvic colon. It was interpreted by the radiologist as a "Stenosing scirrhous type of adenocarcinoma of the pelvic colon" (Fig. 2).

Treatment.—Decompression and cleansing of the distal bowel were accomplished by means of enemas. The patient was given neomycin-oxytetracycline (Enterobiotic) tablets (4 every 4 hours for 48 hours) prior to surgery. On Aug. 31, the abdomen was explored through a left-lower-quadrant, paramedian incision. The midsigmoid colon was found to be almost totally obstructed. A constricting band, consisting of an epiploic appendage, was seen to extend from the medial wall of the sigmoid over the antimesenteric surface of the bowel, attaching itself to the lateral abdominal wall.

Fig. 2 (Case 2).—Typical "napkin ring" obstruction of the descending colon. This was interpreted by the radiologist as "stenosing scirrhous type of adenocarcinoma of the colon." At operation the obstruction was found to be due to an overlapping epiploic appendage constricting the antimesenteric surface of the colon.

The large bowel above the obstructed area was distended, as was the terminal ileum. The constricting epiploic appendage was simply ligated at its base and excised, thus relieving the obstructing mechanism. Exploration of the abdomen was otherwise negative.

Subsequent Course.—The patient had an uneventful convalescence and began having bowel movements on the third day following operation.

The urinary infection and pyelonephritis, for which he was originally admitted, were subsequently managed by the urology service.

Treatment

The surgical treatment of this condition is generally simple and rewarding. Both these patients were cured by simply releasing and excising the involved appendage, allowing ready reexpansion of the large bowel, with an adequate lumen.

Comment

Epiploic appendagitis, although rare, deserves consideration as a cause of acute localizing abdominal pain, particularly when appendicitis has been ruled out by previous appendectomy or the operative finding of a normal appendix. Epiploic appendagitis as a cause of intestinal obstruction is so rare as to be scarcely worth preoperative con-

sideration. Indeed, there is nothing typical or pathognomonic about the preoperative findings, including the x-rays. It is, however, a rare cause of mechanical bowel obstruction, which is easily corrected by operative intervention.

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Pancreatic Carcinoma

Disparity in Size of Neoplasm as Compared with Size of Gross Tumefaction

LEMUEL BOWDEN, M.D., New York

During the 20 odd years since its first successful execution in man, pancreatoduodenectomy has enjoyed a varying popularity in the definitive treatment of periampullary cancer. It has now been accepted as the procedure of choice for the ablation of cancers of the duodenum, including those that arise in the ampulla of Vater. For cancers arising in the head of the pancreas, however, it has never been generally employed. Many experienced surgeons in dealing with cancers of the pancreatic head have, until recently, advocated merely the establishment of a biliary-enteric shunt for the relief of jaundice, in preference to resection of the pancreas and duodenum. This pessimistic trend has been followed because of the high operative morbidity and mortality rate of pancreatoduodenectomy, because of the negligible long-term salvage of patients who survive the procedure, and because of the belief that patients live longer and more comfortably following a biliary shunt than following pancreatic resection.

The past six years, however, have seen the sporadic appearance of case reports of five-year salvage following pancreatoduodenectomy [1-8] for cancer of the pancreas. While the total number of such cases is few, they, nevertheless, have revived interest in the application of this procedure to pancreatic cancer. Most abdominal surgeons today feel that if a pancreatic cancer has not penetrated through the capsule of the pancreas, and if regional lymph nodes are uninvolved by metastasis, then pancreatoduodenectomy for carcinoma of the head of the pancreas is warranted.

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From the Gastric Service, Memorial Center for Cancer and Allied Diseases.

In clinical practice it is often difficult to determine the exact origin of a periampullary cancer and equally difficult to differentiate cancer from chronic inflammation by inspection and palpation. It is quite possible that some patients are denied resection because of misapprehension on the part of the surgeon that cancer has infiltrated beyond the pancreas when such is not the case. The fallibility of pancreatic biopsy has been elsewhere discussed [9] and its pitfalls explained by the frequently associated pancreatitis which surrounds the neoplasm. Furthermore, the size and extent of the actual neoplasm often appear to be quite different from those of the palpable and visible pancreatic tumefaction. Interest in this discrepancy was aroused by the following experience.

Report of a Case

A 69-year-old retired dye worker was admitted to the hospital with a four-month history of jaundice, pruritus, dark urine, and clay-colored stools and a more recent history of back pain. In addition to his marked jaundice, the patient presented a nontender liver, extending 5 fingerbreadths below the costal margin, with a globular, tense, nontender mass palpable just below the liver edge, quite consistent with an enlarged gallbladder. After five days of preparation his abdomen was explored, on March 31, 1952, and an enlarged and thickened gallbladder containing several large stones, a markedly dilated but thin-walled common duct, and a 3×2 cm. mass in the superior aspect of the head of the pancreas were noted. Exploration of the common duct revealed complete occlusion of its distal end by the mass palpable in the pancreas. No common-duct stones were encountered. A transductal biopsy specimen from the area of constriction was reported to show carcinoma. Because of the patient's poor general condition, only tube drainage of the common duct and of the gallbladder was carried out at this time, and the abdomen was closed.

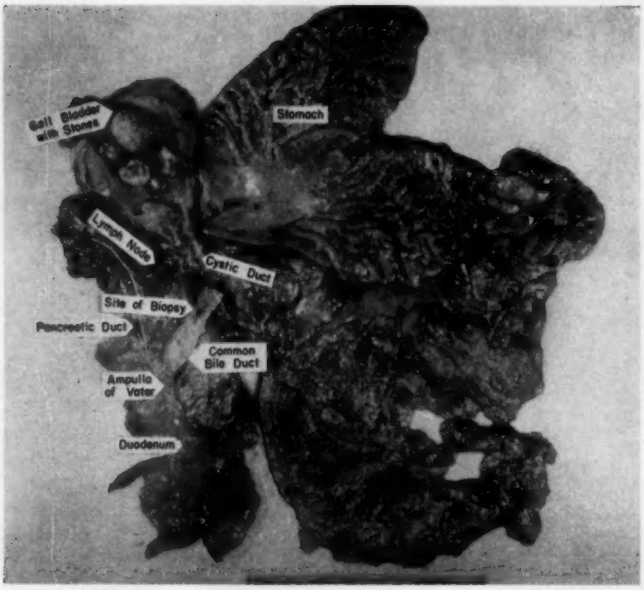

Fig. 1.—Surgical specimen of pancreatoduodenectomy after sectioning in the laboratory, showing the opened common bile duct, the site of positive biopsy specimen, and the absence of grossly recognizable neoplastic tissue.

Four weeks later, on April 28, the patient again underwent laparotomy. The mass in the superior portion of the pancreatic head was again noted but found to measure only 2.5×1.5 cm. Because of the previously obtained positive biopsy tissue, however, pancreatoduodenal resection was undertaken forthwith (Fig. 1). Examination of the surgical specimen is described in part as follows: "The tissue in this area (i. e., the intrapancreatic portion of the common duct) is palpated and examined carefully for any gross evidence of tumor, and none is seen. However, the entire section is sliced at 2 to 3 mm. intervals and submitted in its entirety for microscopic section." Microscopic study revealed the lesion to be an adenocarcinoma with perineural lymphatic spread and metastases to lymph nodes about the common duct. Yet, as indicated in Figure 2, the primary tumor at no point measured more than 2 to 3 mm. in thickness.

Comment.—In spite of the known positive biopsy for carcinoma, the pathologist could not grossly identify tumor on sectioning the surgical specimen.

Fig. 2.—Microscopic section of common bile duct at level of positive biopsy specimen. Under higher magnification the extent and penetration of cancer have been determined and indicated by the ink mark.

Analysis of Clinical Material

The purpose of this paper is to present such additional anatomical data as are available to demonstrate the frequent disparity in size between the gross tumefaction and the actual neoplasm in cancers of the head of the pancreas.

It should be stated at once that the cases analyzed below are not consecutive cases and do not represent total experience with pancreatic carcinoma over the past few years. Only those cases have been employed for this analysis in which at least one linear measurement of the pancreatic tumefaction is provided by surgeon or by pathologist and in which the pathologist, in addition, has described the gross extent of the pancreatic neoplasm on cross-sectional study. The majority of operative and pathologic reports which were reviewed merely described tumors of the head of the pancreas as "large" or as "bulky" or as "twice normal size," and such inexact descriptions are obviously unsuitable for analysis.

Eleven cases in which pancreatoduodenectomy had been done by me or performed by the resident under my direct supervision provided sufficient data for inclusion in this analysis. In addition, Dr. George T. Pack and Dr. Theodore R. Miller have each permitted the use of data obtained from a private operative case of their own. Finally, data from two other of my patients, whose cancers were considered nonresectible at the time of laparotomy but who subsequently died and whose autopsy findings are available in lieu of those from a surgical specimen, are included. A total of 15 cases is thus provided for analysis.

The data provided by these 15 cases are best presented in tabular form (Table). The size of the gross pancreatic tumefaction is recorded either as the surgeon's estimate at the time of exploration or as the pathologist's actual measurement of the fresh surgical specimen prior to its dissection in the laboratory. The latter figure is preferable because of its greater accuracy but was available in only 7 of the 15 cases. In one of these (Case 3) both the surgeon's estimate and the pathologist's measurement of the gross tumefaction are available, and the two values are quite comparable. In the remaining eight patients the somewhat less accurate estimate of the size of the gross tumefaction by the surgeon has been employed.

Compared with the size of the gross tumefaction are the measurements of the actual neoplasm, as revealed by multiple sections through the pancreatic head and precise measurement by the pathologist. It will be noted that in five of the specimens studied no gross neoplasm could be demonstrated on multiple sectioning. All 15 patients were found to have carcinoma of the pancreas on microscopic study, as indicated in the last column of the Table.

Pancreatic Carcinoma

Case No.	Gross Tumefaction		Size of Neoplasm, Cm.*	Histologic Diagnosis
	Surgeon's Estimate, Cm.*	Pathologist's Measurement, Cm.*		
1	4	--	2.2	Adenocarcinoma
2	--	7×6×4.5	4.5×4×3.5	Adenocarcinoma
3	6	6×4.5	3×2	Papillary cystadenocarcinoma
4	8×6	--	None discernible	Adenocarcinoma
5	--	4	1.5	Adenocarcinoma
6†	10	--	4	Adenocarcinoma
7	1.5	--	None discernible	Adenocarcinoma
8	1.5	--	None discernible	Adenocarcinoma
9†	5	--	None discernible	Adenocarcinoma
10	2.5×1.5	--	None discernible	Adenocarcinoma
11	--	9×7×5	4	Adenocarcinoma
12	--	4	2	Adenocarcinoma
13	5	--	1.8×1.3×1.0	Adenocarcinoma
14	--	5×5	3	Adenocarcinoma
15	--	5.5×4.5×3.4	2.4	Adenocarcinoma

* Single figures used above represent, in every instance, greatest diameter.
† Data obtained, in part, at autopsy.

It will be immediately apparent that in every instance here recorded the gross tumefaction was appreciably greater than was the actual underlying neoplasm.

Comment

This disparity between the size of the gross tumefaction in the head of the pancreas and that of the underlying neoplasm is readily explained. The frequent association of pancreatitis with cancer of the pancreas, as a result of neoplastic invasion and obstruction of contiguous pancreatic ducts, is a well-established fact.[9,10] The pancreatic parenchyma surrounding an infiltrating carcinoma therefore presents varying degrees of edema, inflammation, and nodularity, and, as a result of this surrounding pancreatitis, the visible and palpable tumefaction must necessarily be greater than the underlying cancer.

It seems obvious, therefore, that associated pancreatitis generally obscures the true dimensions and extent of an infiltrating carcinoma of the pancreas. This observation does not apply to all cancers of the pancreas. Immediately there comes to mind a recent pancreatoduodenectomy, readily performed, for a tumor of the pancreatic head in which the dimensions of both the gross tumefaction and the neoplasm were 14×10×8 cm. and which, on microscopic study, was shown to be a well-differentiated adenocarcinoma, believed to be of islet-cell origin. Even though this tumor had apparently replaced the entire head of the pancreas and had greatly expanded the duodenal loop, the common bile duct was of normal caliber and the patient had at no time been jaundiced. This latter tumor was noninfiltrative and largely observation supports the thesis that this exophytic.

It is also recognized, of course, that the mere size of an infiltrating carcinoma of the pancreas bears no relationship whatsoever to its curability. In fact, the infiltrative type of carcinoma, regardless of size, doubtless has a worse prognosis than any other type of pancreatic cancer.

The significance of this observation concerning the disparity in size between the gross tumefaction and the underlying neoplasm in cancer of the pancreas is evident. If any potentially curative treatment is to be offered the patient with cancer of the pancreas, then at the present time and in the immediately foreseeable future it must be surgical resection. If surgical resection of the pancreas is to be aggressively applied, the operating surgeon must be cognizant of the fact that the bulk of a pancreatic tumefaction is no contraindication, necessarily, to surgical resection and that the actual size of the cancer itself may be considerably smaller than the visible and palpable mass encountered in the course of pancreatic resection.

Summary

On the basis of comparative measurements in 15 patients with histologically proved carcinoma of the head of the pancreas, it has been shown that the gross tumefaction in the head of the pancreas was appreciably greater than was the underlying neoplasm.

The mere size of a mass in the head of the pancreas is, therefore, no contraindication in itself to resection if resection is otherwise feasible.

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Diverticulitis of the Right Colon

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Historical Background

In 1849 Cruveilhier first described colonic diverticula. In 1853 Virchow first described the inflammatory disease and named it diverticulitis. Bristowe, Jones, Habershon, Lane, Graser, and Bland-Sutton contributed to the early literature.[1] In 1907 Mayo reported five cases of sigmoid resection for diverticulitis, and he is credited with the first surgical application. The greatest impetus to the study of this entity came in 1913, when de Quervain, in Switzerland, made the diagnosis by x-ray. The next year Case, in the United States, reported criteria for x-ray diagnosis.[2] It soon became evident that diverticulosis and diverticulitis were most frequently found in the left colon. This report, however, is concerned primarily with the right colon. The first case of cecal diverticulitis was described by Portier in 1912.

Pathology

Diverticulum of the right side is a pathological entity distinct from that of the left side. Right-sided diverticula are usually solitary. They are true diverticula and contain all coats, in contradistinction to the left-sided lesions, where there is herniation of the mucosa through the muscular coat. The latter should be called pseudodiverticula. The right-sided lesions are probably congenital in origin, whereas the left-sided ones are acquired. It is interesting to note that in extensive diverticulosis the lesions may reach the right side, diminishing in frequency as they go toward the cecum; but one rarely, if ever, finds pseudodiverticula solely on the right side.

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From the Surgical Services of Coney Island Hospital.

Etiology

Ellis[3] has reviewed many etiological theories of cecal lesions. These include (1) eversion of the cecal wall between two constricting anatomical bands; (2) traction by adhesions; (3) eversion of a weak spot caused by migration of a purse-string suture; (4) appendiceal-stump abscess; (5) inherent cecal-wall weakness; (6) increased intracolic pressure.

None of the above theories seem reasonable. Diverticulitis occurs most frequently in the absence of previous appendectomy, and a study of intracolic pressure hardly leads one to believe that this factor could be a cause of true diverticulum formation. The theory that seems most plausible is that these diverticula are related to the transient multiple appendices seen in the embryo.

Incidence

Diverticulitis of the right colon is uncommon. In 1952 Lauridsen and Ross[4] reviewed 149 cases of cecal diverticulitis and reported 4 more. In 1953 Vaughn and Narsete[7] could find only 14 cases of diverticulitis of the ascending colon and added 2 cases. Mears et al.[6] reported the first case of diverticulitis of the hepatic flexure. They found 2 cases of diverticulitis of the ascending colon and 13 cases of the cecum in the files at the Mayo Clinic.

The age incidence of diverticulitis of the right side is about a decade lower (41.8 years in one series) than that of the left-sided disease. The youngest case of right-sided diverticulitis was reported by Odqvist and Petrén in 1931.[8] It occurred in a 3-year-old girl and was an incidental finding at autopsy. Some reports record a higher incidence in males, but the number of cases

Summary of Cases

CASE NO.	AGE	SEX	SITE	OPERATION	PRESENTING SYMPTOM OR SIGN	NAUSEA AND VOMITING
1	59	M	CECUM	MIKULICZ	PAIN—48 HOURS	0
2	22	M	CECUM	LOCAL RESECTION	PAIN—60 HOURS	0
3	53	M	ASCENDING COLON	OBSTRUCTIVE RESECTION	PAIN—36 HOURS	0
4	48	F	ASCENDING COLON	RIGHT HEMICOLECTOMY	PAIN-24 HRS.-MASS	0
5	47	M	ASCENDING COLON	OBSTRUCTIVE RESECTION	PAIN—12 HOURS	0
6	40	M	CECUM	OBSTRUCTIVE RESECTION	PAIN-36 HRS.-CHILL	0
7	65	F	CECUM	LOCAL RESECTION	PAIN—6 DAYS	0

is so sparse that this variation is not considered statistically significant.

Diagnosis

Anderson reported the preoperative diagnosis in 6% of 99 cases which he studied.

In cases of diverticulitis of the right colon the preoperative diagnosis is almost invariably one of acute appendicitis or a perforated malignancy of the cecum. The presenting symptom is usually pain. A palpable mass in the right lower quadrant has been found with sufficient frequency to make it a diagnostic aid. One factor which may be of some importance is the absence of nausea or vomiting in all of our cases. This is consistent with the finding of a low incidence of nausea and vomiting in diverticulitis on the left side. Pain in the right lower quadrant, a mass in the right lower quadrant, and the absence of nausea and vomiting should raise the index of suspicion of the presence of cecal diverticulitis.

Treatment

Many factors enter into the problem of treatment. More conservative measures include inversion of the diverticulum by a purse-string suture; local resection of the diverticulum; placing a drain in the abscess cavity, if present, or simply closing the abdomen without drainage. The more radical measures include exteriorization and right hemicolectomy. Each case must be individualized, and good judgment on the part of the surgeon is paramount to any rule of thumb. In no case in this series was it feasible to invert the inflamed diverticulum. Theoretically this procedure would be desirable, but it should be used only where the inflammatory process is localized sufficiently to allow suture of uninvolved tissue. In this series, local resection was performed twice. In Cases 2 and 7 the pathology was obvious, and in both instances the tip of the cecum was involved. There was sufficient localization to permit one to resect the lower end of the cecum, do a two-layer closure, and yet avoid compromising the ileocecal valve. In four instances an exteriorization procedure was done—three of the Rankin obstructive type and one of the Mikulicz type. Two factors influenced these decisions. First, differentiation between inflammation and malignancy was impossible. Second, these operations were done as emergencies, and the bowel was not prepared. In the presence of infection with a question of malignancy present, exteriorization offers a relatively safe method of treatment. Its disadvantages are that it necessitates another operative procedure and it produces an ileostomy, with its concomitant stresses. In one instance, a right hemicolectomy was performed as a primary procedure.

Report of Cases

CASE 1.—A 59-year-old white man was admitted to the hospital on Feb. 5, 1949, with a 48-hour history of pain in the right lower quadrant. There was no nausea, no vomiting. The white blood cell count was 12,900 per cubic millimeter, with 86% polymorphonuclear leukocytes. A preoperative diagnosis of acute appendicitis was made. At operation, a gangrenous, perforating diverticulum of the anterolateral cecal wall, involving the appendix, was found. A Mikulicz procedure was done. The patient made an uneventful recovery and was discharged after 35 days of hospitalization. Two months later he was readmitted and the second stage was completed.

CASE 2.—A 22-year-old white man was admitted to the hospital with a 24-hour history of pain in the right lower quadrant; there was no nausea, vomiting, or palpable masses. A preoperative diagnosis of appendicitis was made. At operation the appendix was observed to be covered with a thick inflammatory exudate. As the base of the appendix was exposed, it was evident that the lowermost tip of the cecum was the site of a perforated diverticulitis. It was technically feasible to resect the distal tip of the cecum and do a two-layer

Fig. 1 (Case 1).—Probe is through the perforated cecal lesion.

closure on uninvolved tissue without compromising the ileocecal valve. The patient made an uneventful recovery. Five and one-half years later the patient presented himself with a mass in the right lower quadrant. At operation a large adenocarcinoma of the cecum with metastases to the liver was found. The original specimen was reviewed, and no evidence of malignancy was found. This patient was a member of a family with a strong history of malignancy. A palliative right hemicolectomy was performed at the second operation. He died seven months later of metastatic carcinoma.

Case 3.—A 53-year-old white man was admitted to the hospital with a 36-hour history of pain in the right lower quadrant. There was no nausea or vomiting, and no masses could be palpated. A preoperative diagnosis of acute appendicitis was made. The white blood cell count was 17,700 per cubic millimeter, with 94% polymorphonuclear leukocytes. At operation a perforated diverticulitis of the ascending colon with pericolonic abscess was found. A Rankin procedure was performed. The patient was discharged after 32 days of hospitalization, and he returned in two months for the closure of the ileocolostomy.

Case 4.—A 48-year-old white woman was admitted on Dec. 24, 1952, with a 24-hour history of pain in the right lower quadrant. There was no nausea or vomiting. On rectal examination a mass could be felt on the right side. The patient was observed for several hours, and her leukocyte count rose from 12,000 to 16,500 per cubic millimeter. Because of increasing signs, a laparotomy was performed, and a ruptured diverticulitis of the ascending colon was found. A one-stage right hemicolectomy was performed. The patient made an uneventful recovery and was discharged two weeks following operation.

Fig. 2 (Case 3).—Perforation is in the ascending colon.

Case 5.—A 47-year-old white man was admitted to the hospital on Sept. 27, 1947, with a 48-hour history of pain in the right lower quadrant. There was no nausea or vomiting, and no masses were

Fig. 3 (Case 5).—Perforation is evident in the ascending colon.

palpated. A preoperative diagnosis of acute appendicitis was made. At operation a ruptured diverticulitis of the ascending colon was found, and an obstructive resection of the Rankin type was performed. The patient was discharged after two weeks of hospitalization. Twenty days later he was readmitted as an emergency, complaining of pain in the chest, and died within an hour. The clinical impression given by his attending physician, at that time, was acute coronary occlusion. The only significant point in the history was a profuse diarrhea from the ileostomy for five days prior to admission. The significance of this symptom preceded the newer knowledge of potassium loss, and in retrospect this case may very well have been one of hypokalemia.

CASE 6.—A 40-year-old white man was admitted to the hospital on Feb. 25, 1950, with a 36-hour history of pain in the right lower quadrant and right costovertebral tenderness. The onset of the pain was accompanied by a chill. There was no nausea or vomiting. There were right-lower-quadrant tenderness, rebound, and spasm. The temperature was 100 F, and the white cell count was 12,000 per cubic millimeter. At operation a ruptured diverticulum of the proximal portion of the cecum was found. An obstructive resection of the Rankin type was performed. The patient made an uneventful recovery, and six weeks later bowel continuity was reestablished.

CASE 7.—A 65-year-old woman was admitted to the hospital on May 4, 1950, with a history of pain in the right lower quadrant of six days' duration. There was no nausea or vomiting. The temperature was 100 F, and the white cell count was 21,000 per cubic millimeter. At operation a ruptured diverticulum of the proximal portion of the cecum was found. A local resection was performed. The patient made an uneventful recovery.

Comment

Diverticulitis of the right colon is probably commoner than is stated in the literature. Many single cases are not recorded; some cases are not recognized, and in some instances a diagnosis of ulcer or granuloma is made.

There was one death in this series. Case 4 had an exteriorization procedure and was discharged. He was readmitted 34 days after operation and died within an hour. His chief complaint was chest pain, and the clinical impression was acute coronary occlusion. The patient had had diarrhea from the ileostomy for five days prior to admission. This was associated with lassitude. In retrospect, it is possible that this case was one of hypokalemia. This case dates back to 1947, and, had the newer knowledge of potassium loss been at hand, the death might have been averted.

Case 6, a 22-year-old man, developed a malignancy of the cecum five and one-half years after local resection. The original slides were reviewed, and the absence of malignancy was confirmed. It is unlikely that there was any relationship between the two conditions.

The diagnosis is usually evident at operation. However, when acute appendicitis is suspected and a normal appendix is found, the ascending colon should be examined with suspicion.

When circumstances permit, conservative surgery should be performed. Ill-advised conservatism may, however, become the most hazardous method. With fluid replacement, antibiotics, and good anesthesia available, hemicolectomy is the most desirable pro-

cedure for the severer cases. In a good-risk patient it is a satisfactory definitive procedure, reduces the hospital stay, and eliminates the problems associated with an ileostomy. In poor-risk cases, or where peritoneal soiling is extensive, exteriorization may be the procedure of choice. However, as experience accumulates, it is felt that primary hemicolectomy will be done more frequently in the future than in the past.

Summary

1. Seven new cases of diverticulitis of the right colon are added to the literature.

2. Historical, diagnostic, and therapeutic aspects are discussed.

3. Primary right hemicolectomy is advocated as the procedure of choice in severe cases.

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Orchiectomy with Epididymal Prosthesis

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Carcinoma of the prostate gland must often be treated by bilateral orchiectomy. The most popular method involves bilateral total epididymo-orchiectomy, and many urologists utilize subcapsular orchiectomy, retaining the tunica albuginea and epididymis as a testicular prosthesis. Others have advocated the use of plastic prostheses. Review of the urological texts and the periodical literature failed to reveal a method by which the testis is completely excised with its tunica and the epididymis is utilized as a substitute for the testicular mass.

Many patients with carcinoma of the prostate are reluctant to permit bilateral orchiectomy when they know there will be complete absence of any scrotal content. Certainly it is a source of masculine satisfaction to palpate some sort of a soft tissue within the scrotum.

The method presented in the accompanying illustration has been used for some years and was originally described to me by Dr. William Boyce, of the Bowman Gray School of Medicine of Wake Forest College. When this method is used, the patient can be told that the portions of his testes which stimulate his prostatic tumor will be removed, but the entire scrotal contents will not be removed. This simple, yet truthful, explanation overcomes much of a patient's reluctance to surgery.

As illustrated, the testis may be mobilized from the epididymis by blunt and sharp dissection with a scissors. A minimum of sharp dissection is necessary. In two or three minutes the testicular blood supply is usually delineated into three separate groups of vessels. These vessels are easily clamped, divided, and ligated with 0 chromic absorbable surgical (gut) suture, thereby freeing the testis. The epididymis alone remains, but there is often a slightly oozing vascular area adjacent to the ligated main hilar vessels. A running suture of 00000 Atraumatic chromic gut is used to draw a layer of parietal tunica vaginalis over the hilar vessels. This serves to complete hemostasis by providing some tissue resistance to capillary bleeding. The two opposing ends of the epididymis are drawn together with the ends

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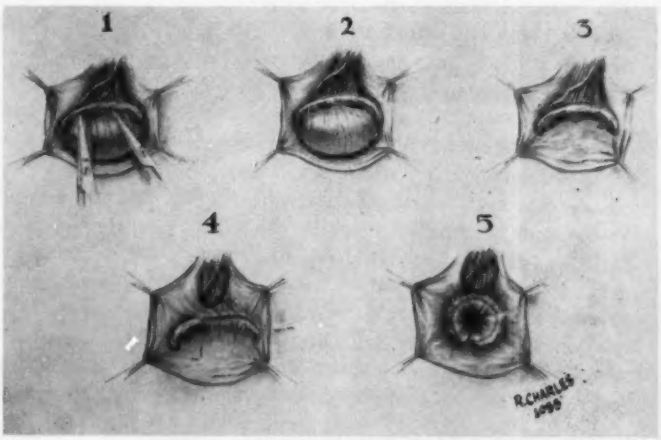

Surgical method for creating epididymal prosthesis. After the testis is removed (*3*), tunica vaginalis is sutured over the epididymis (*4*), and the two ends are drawn together (*5*). This creates a mass almost equal to that of the testis.

of the running suture, and a mass almost equal in size to the original testicle is created. A Penrose drain is placed in the wound; the skin edges are approximated, and a pressure dressing is applied.

Proof of the adequacy of this procedure is that third-year medical students have been asked to examine patients who have undergone orchiectomy in this manner, and to describe their findings. The majority of these students were unaware, after examination, that the testes had been removed and that only the epididymides remained.

I do not claim credit for originally devising this procedure, but lack of previous publication and its successful use over a period of four years would suggest that the method is worthy of presentation.

Summary

A method of total orchiectomy is described. The remaining epididymis is covered by tunica vaginalis and is folded to form a testicular prosthesis.

Sgt. Richard Charles, of the 5005th U. S. Air Force Hospital, made the illustrations.

190 Mill St.

Infected Urachal Cysts

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Diseases of the urachus are uncommon clinical entities, evidenced by the relatively small number of case reports in the literature. Since 1550 approximately 400 cases of urachal disease have been reported, of which more than 200 were of infections. However, many of these cases are poorly documented or unproved. Thus, in his recent review, Sterling[4] was able to collect only 26 proved cases of infected urachal cyst with onset of symptoms after the age of 5 years. It is the purpose of the present paper to review the embryology, pathogenesis, and clinical features of infected urachus cysts and to add six cases to the literature.

Embryology

In order to achieve adequate insight into urachal disease, brief reference must be made to the embryology of this structure. Begg[1,2] has demonstrated that the urachus is not the remnant of the allantoic stalk, as was formerly believed, but, rather, is derived from the upper part of the bladder, which in turn is derived from the ventral portion of the cloaca. As the bladder descends from the umbilicus in early fetal life, its apex elongates and attains a conical shape. This structure is known as the urachus, and it retains the essential histologic features of the urinary bladder, including an active urothelium. The urachus descends from the umbilicus with the bladder, remaining in a retroperitoneal position. Various degrees of failure of descent may occur, the extreme being represented by the umbilicovesical fistula, or so-called patent urachus.

Submitted for publication Nov. 12, 1957.

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Pathogenesis

Simple cysts of the urachus are not infrequently discovered incidentally at autopsy,[15] having been asymptomatic during life. Their origin is obscure, though several theories have been proposed.[1,2,3,9,11] Whatever their development, it would appear that clinical diseases of the urachus represent simply complications of the urachal cyst. Of these complications, infection is by far the commonest. Others are malignancy, tuberculosis, and calculus formation.

Infection may reach the cyst in a variety of ways. It may ascend from the bladder via the lymphatics or inside the urachus, descend from the umbilicus, or be of hematogenous origin. No correlation between poor umbilical hygiene and infection of the urachus has been made, nor has experience shown any in the cases to be presented. The incidence of urinary disease, especially diseases of the prostate, seems rather high in the reports of others, but, again, this was not a finding in our cases.

Incidence

Infected urachal cysts occur in males and females with approximately equal frequency.[3] They are rare beyond the fifth decade of life. From 1946 through 1955 there were 14,699 admissions to the surgery and urology services of the Methodist Hospital, of which 5 were for infected urachus cyst. During the same period of time there were 20,264 admissions to the surgery and urology services of the Jefferson Davis Hospital, of which 1 was for infected urachus cyst. One of the Methodist Hospital cases was treated by incision and drainage by another physician; hence, having had no pathologic confirmation, it is not included in this report. In the other case (Case 6) to be reported

Fig. 1.—Umbilicus, with typical appearance of cherry-red granuloma surrounded with purulent exudate.

the operation was done by one of us (W. B. G.) at another hospital.

Clinical Manifestations

Earlier schemata of classification, based on the premise that the urachus cyst arises from an imperfectly obliterated allantoic stalk, may easily be adapted to present-day concepts. As the infected cyst expands in volume, it will dissect along the path of least resistance in one of two directions—inside the urachus to the umbilicus or inside the urachus to the urinary bladder—or rupture into the peritoneal cavity.

The urachus has been demonstrated by Begg to be microscopically patent, in nearly all adults, probably explaining the rarity of direct rupture into the peritoneal cavity. Umbilicovesical fistula (patent urachus) is purposely omitted from this discussion because it represents a separate problem developmentally and clinically. The urachoumbilical type is characterized by infraumbilical pain, chills, fever, inability to stand erect (due to rectus spasm), variable peritoneal signs, and occasional vomiting. The appearance of purulent discharge from elevated, reddened nodules of granulation tissue in the umbilicus confirms the diagnosis. Little difficulty is encountered in differentiating vitelline-duct cysts or fistulae.

The urachovesical type is an uncommon cause of sudden and persistent urinary-tract infection. The diagnosis may be suspected in the presence of cryptogenic infection of the lower urinary tract, preceded by low midline pain, fever, etc. These cysts may be demonstrated by cystoscopy and cystography but are difficult to differentiate from bladder diverticula.

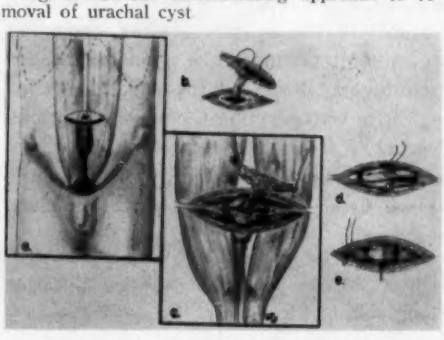
The peritoneal type, in addition to preliminary signs and symptoms already noted, may present one or more of the following features: low midline mass, generalized peritonitis, or multiple enteric fistulae. It is almost never diagnosed preoperatively.

Treatment

With the advent of antibiotics, there has been a trend toward primary excision of the infected urachal cysts. Prior to 1942, treatment in most cases was by simple drainage, curettage, or marsupialization, excision being deferred until control of the infection was obtained. It is now becoming evident that with antibiotic coverage the majority of cases respond well to primary excision and are accompanied by little, if any, morbidity.

In the majority of cases, representing those in which the diagnosis is unsuspected or in serious doubt, exploration will be made through midline or rectus incisions. However, a transverse elliptical incision about the umbilicus affords certain technical advantages. The edges of the ellipse are oversewn with a continuous suture (Fig. 2), thus minimizing contamination from the

Fig. 2.—Sketch demonstrating approach to removal of urachal cyst



umbilicus, and the dissection is continued into the peritoneal cavity superiorly. From this point, the removal of the intact retroperitoneal cyst may be accomplished with relative ease. The dissection may be carried to the apex of the bladder, if necessary.

Report of Cases

CASE 1.—A 31-year-old white physician had had periumbilical pain, tenderness, fever, and purulent umbilical discharge for three weeks prior to admission to the Methodist Hospital. He had also noted frequency of urination and umbilical pain on urination. In spite of self-treatment with chlortetracycline (Aureomycin), erythromycin, and local silver nitrate, he had failed to improve. On admission, physical examination was within normal limits save for periumbilical tenderness and a cherry-red granuloma in the umbilicus. He was afebrile. The urine and x-rays were negative. Hemoglobin was 16 gm. per 100 cc., and the white cell count was 13,600 per cubic millimeter, with 75% segmented forms. On Oct. 31, 1953, a urachus cyst was excised primarily. Recovery was uneventful, and the patient was discharged on the 10th hospital day. Pathologic examination (Methodist Hospital) revealed a cyst partially lined with squamous epithelium and filled with keratin, pus, and amorphous material.

CASE 2.—A 35-year-old white man was admitted to the Methodist Hospital with a one month's history of pain and swelling about the umbilicus. Two days later purulent discharge from the umbilicus was noted. One week prior to admission he had been hospitalized elsewhere and treated with antibiotics unsuccessfully. Physical examination was within normal limits save for a cherry-red granuloma in the umbilicus, from which purulent material drained. All laboratory studies, including urinalysis and roentgenography, were within normal limits save for the white blood cell count, which was 11,000 per cubic millimeter, with 61% segmented forms. On Dec. 13, 1953, a urachus cyst was excised primarily. Recovery was uneventful, and the patient was discharged on the 10th hospital day. Pathologic examination (Methodist Hospital) revealed a cyst lined by fibrous tissue and filled with keratin and pus.

CASE 3.—A 44-year-old white man was admitted to the Methodist Hospital with a two weeks' history of cramping periumbilical pain, fever, and one episode of vomiting, diagnosed by his local physician as "indigestion." Ten days prior to admission, purulent material had commenced to drain from his umbilicus, the condition having been diagnosed by another physician as an "infected insect bite." Drainage persisted in spite of antibiotics, though the pain lessened. Physical examination on admission revealed infraumbilical tenderness and a cherry-red granuloma in the umbilicus. Routine laboratory examinations, including urinalysis, were within normal limits, as were x-rays. On Feb. 11, 1956, a urachus cyst was excised primarily. Recovery was uneventful, and the patient was dismissed on the seventh hospital day. Pathologic examination (Methodist Hospital) revealed a cyst lined by fibrous tissue containing the products of chronic and acute inflammation.

CASE 4.—A 60-year-old white man was admitted to Jefferson Davis Hospital on Nov. 8, 1949, with a three months' history of purulent discharge from the umbilicus. At the onset of the illness, the patient had noted an infraumbilical mass and fever. Physical examination on admission was within normal limits save for a reddened granuloma in the umbilicus. Routine laboratory studies were within normal limits. Primary excision was followed by an uneventful recovery, and the patient was dismissed on the ninth hospital day. Pathologic examination (Jefferson Davis Hospital) revealed a cyst lined by fibromuscular tissue, in which there were foreign-body giant cells and necrotic debris.

CASE 5.—A 40-year-old white man had noted an irritation in the area of the umbilicus approximately one month prior to his admission, on Nov. 28, 1956. The tenderness in the umbilical region progressed, and approximately three weeks prior to admission the umbilicus began to drain pus. This condition was treated by his local doctor with penicillin and heat, and approximately one week prior to admission he was given two minutes of external x-irradiation. The condition did not improve, and the patient was referred for further treatment.

Examination revealed an area of redness and induration surrounding the umbilicus, the cherry-red granuloma within the base of the umbilicus, and pus exuding around it. The white blood cell count was 11,100. X-rays of chest and abdomen were negative. Urinalysis was normal.

Treatment consisted of warm saline compresses, broad-spectrum antibiotics, and surgical excision of the umbilicus and urachus on the sixth day after hospital admission, Dec. 3, 1956. Pathologic examination (Methodist Hospital) confirmed the diagnosis of a developmental cyst, with acute and chronic inflammatory reaction, urachal in origin.

CASE 6.—A 31-year-old white man was admitted to the Bertram Hospital, Bertram, Texas, on Aug. 6, 1954. A purulent discharge from the umbilicus had begun 10 days prior to admission and had continued, with increasing periumbilical soreness. There was no history of prior episodes of this nature, and the patient felt that he had possibly hurt himself in lifting during construction of a house. Examination revealed a discharge from

the umbilicus of a purulent nature, associated with a cherry-red granuloma and induration of the surrounding skin. There was tenderness to light touch in this area. No signs of peritoneal irritation were present. The white blood cell count was 13,500. Operation was performed, and recovery was uneventful. Pathological examination (Methodist Hospital) revealed a urachus cyst with subacute and chronic inflammation.

Summary

Six cases of infected urachal cysts are presented. The embryology and method of treatment are discussed. It is felt that, with early recognition and treatment, complications may be averted.

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Reinforcement of Vascular Grafts with Viable Intestinal Segments

Five-Year Follow-Up Study

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In an experimental study that began in 1947, intestinal segments were used as a means of replacing or reinforcing structures in the thorax and the abdomen.[1-4] One phase of this study dealt with the reinforcement or reconstruction of vascular grafts in animals.[2,5] Another phase was concerned with an unsuccessful attempt at reconstructing an intima from inert materials—cast gelatin tubes, rolled gelatin tubes, glucose tubes, and dicetylphosphate.

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Several animals of a series in which viable intestinal segments were used to reinforce vascular grafts have survived for five years. The procedure used in the reinforcement of these vascular grafts with viable intestinal segments is illustrated in Figure 1 and has

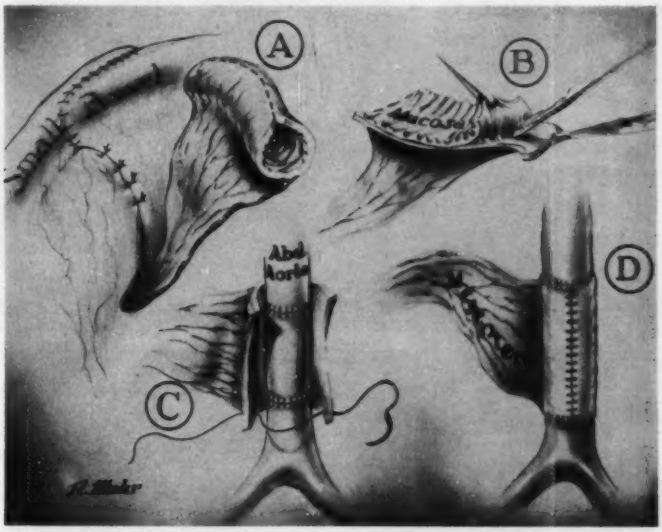

Fig. 1.—Method of preparing the pedicle flap of the intestine, removing the mucous membrane, and applying it around the blood vessel graft.

Results of Reinforcement of Vascular Grafts with Intestinal Segments

	No. Dogs	Results	Postoperative Complications
Gelatin tubes plus intestinal segment	3	Poor	Thrombosis
Rolled gelatin tubes plus intestinal segment	3	Poor	Rupture and hemorrhage
Glucose tubes plus intestinal segment	4	Poor	Thrombosis
Dicetylphosphate plus intestinal segment with mucosa removed	3	Poor	Abscess
Dicetylphosphate plus intestinal segment with mucosa intact	3	Poor	No fibrosis
Vein plus intestinal segment	10	Good	Patent
Artery plus intestinal segment	10	Good	Patent
Plastic plus intestinal segment	3	Good	Patent

Fig. 2.—Graft after two years in an animal.

been fully described in a previous article.[5] Gross and microscopic studies, as well as drug studies, have been made of the reinforced grafts.

Results

It can be seen in the accompanying Table that the best results were obtained by using arteries, veins, or plastic grafts and reinforcing them with viable intestinal segments. The complications encountered were usually on the basis of infection or the result of incompletely removing the mucous membrane from the segment of intestine. In these cases a gradual occlusion and thickening of the remaining intima were produced. These degenerative changes are similar to those described by Szilagyi in his studies in humans.[6]

Figure 2 shows a graft reinforced by a segment of bowel approximately two years

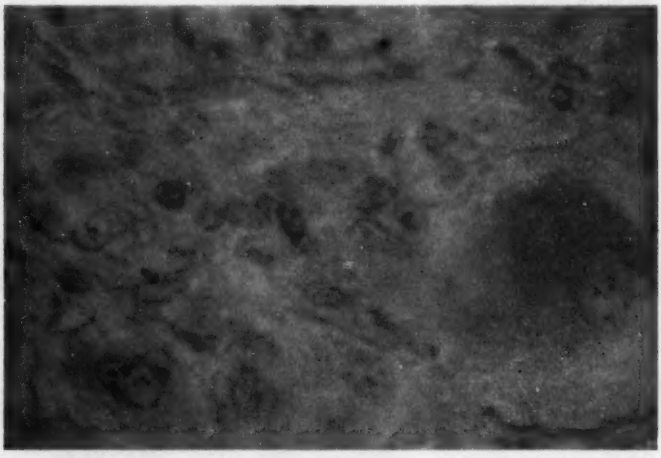

Fig. 3.—Auerbach's plexus, demonstrable after five years. Hematoxylin-eosin stain; reduced to 62% of mag. × 800.

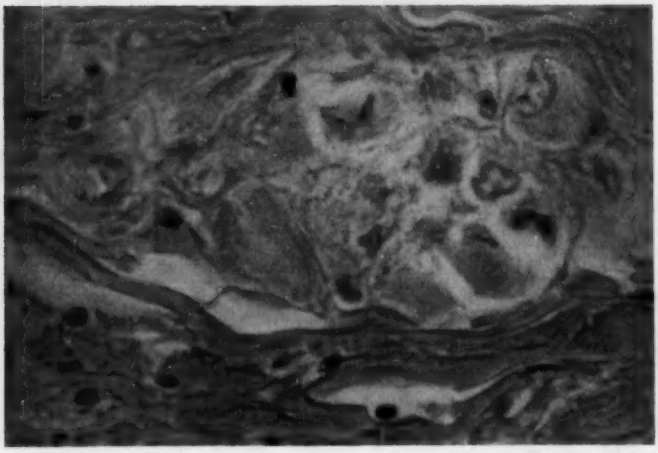

Fig. 4.—Meissner's plexus, demonstrable after five years. Hematoxylin-eosin stain; reduced to 62% of mag. × 800.

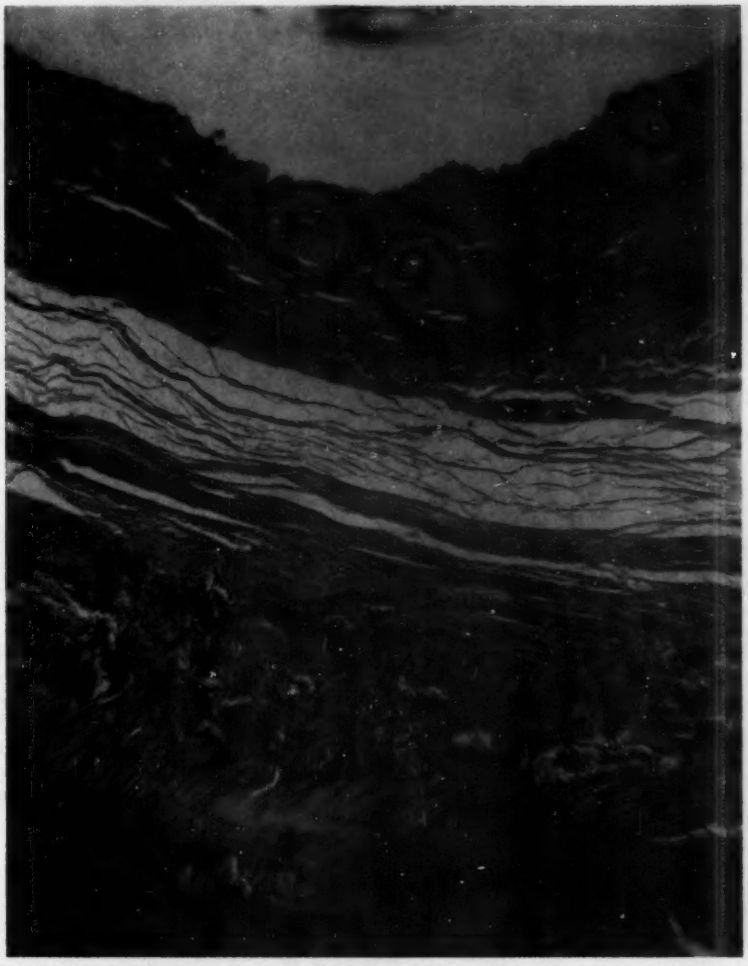

Fig. 5.—Junction between the arterial graft and the intestinal segment. Note that after several years there is no sign of granuloma formation and no cellular infiltration. There is a fibrous union between the intestinal segment and the blood vessel graft. Gridley quadruple stain; reduced to 64% of mag. × 110.

after surgery. It will be noted that there is not much fibrosis and no infection around the graft, and that there is no dilatation. Studies proved that this graft was still alive and that it responded to drugs. Methscopolamine (Pamine), for instance, caused relaxation, while tetraethylamonium (Etamon) and methacholine (Mecholyl) produced contraction. After five years that graft could still be isolated and it still reacted to drugs. When the grafts were sectioned, Meissner's and Auerbach's plexuses could be located and the ganglion cells demonstrated, as shown in Figures 3 and 4.

When the segments were examined microscopically, intimal changes were no more marked than those found in unreinforced grafts of the same age. Figure 5 shows that there was no evidence of granuloma formation or infection at the end of five years. In some of the grafts in which the mucous membrane was left inadvertently the mucosa continued to secrete. This secreted mucus formed a cyst which gradually enlarged and

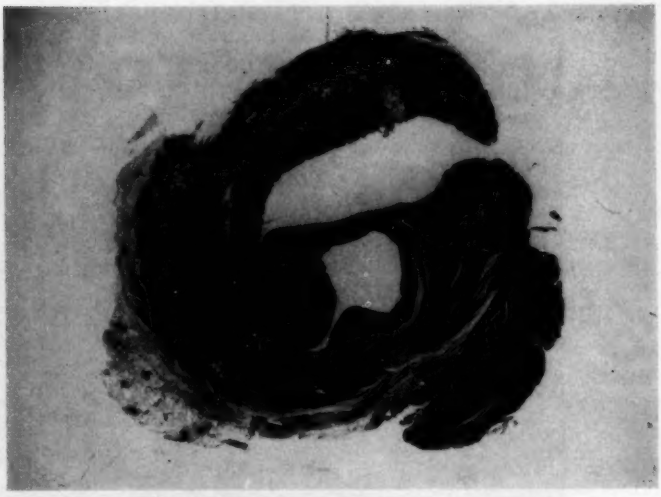

Fig. 6.—Graft reinforced by a segment of intestine in which the mucosa has been left inadvertently. Notice that the mucous cyst has produced compression of the vascular graft. Gridley quadruple stain; reduced to 77% of mag. × 8.

Fig. 7.—Graft farther down, distal to one of the cysts that form between the intestinal segment and the graft, showing that complete occlusion did occur distal to it. Gridley quadruple stain; reduced to 77% of mag. × 8.

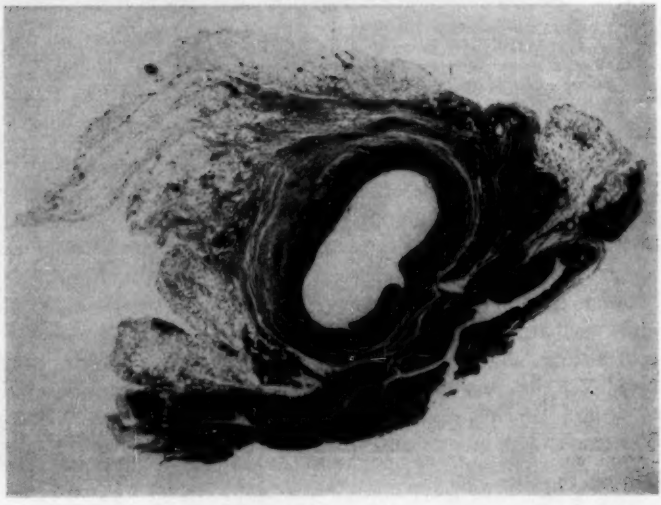

Fig. 8.—Blood vessel segment in which the graft unfolded and adhered to only one part. Apparently the adherent part is the place where the intimal reaction occurred in the graft itself. Gridley quadruple stain; reduced to 77% of mag. × 8.

occluded the lumen of the graft (Fig. 6). This progressed to occlusion of the entire graft (Fig. 7).

In other grafts the intestinal segment apparently unfolded and was adherent to only one side of the graft (Fig. 8). These vessels showed some intimal thickening and degenerative changes similar to those demonstrated by Szilagyi.[6] The grafts themselves had not occluded and showed no dilatation. However, they probably had not gone long enough.

Summary

1. In animals artery and vein grafts reinforced with viable intestinal segments showed no dilatation after five years.

2. The intestinal segments were still alive and functioning with no evidence of infection.

3. Mucous cysts occurred in areas where the mucosa was left intact and produced a gradual occlusion of the graft.

4. Intimal changes, which consisted of thickening of the intima itself, occurred in the artery or vein graft after five years.

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Permanent Cervical Esophageal Stoma in Trained Dogs

An Experimental Technique

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Introduction

Cervical esophagostomy has been variously utilized in the experimental laboratory for sham feeding, for introducing food into the stomach without its being masticated, or for collecting specimens of saliva. The classic operation is done in two stages: A loop of cervical esophagus is first exteriorized, and later a double stoma may be produced, or the distal limb may be occluded if desired. When either preparation is used, the maintenance of nutrition obviously is a problem, and the procedure is therefore undesirable for a long-term experiment.

The following procedure produces a cervical fistula which allows easy passage of a tube or catheter into the distal part of the esophagus and yet, by its position and size, allows little loss of saliva or food. Consequently, the animals remain in excellent physical condition without the need for special care.

Operative Technique

With the aid of intravenous pentobarbital anesthesia, a midline cervical incision is made from the cricoid cartilage to the sternal notch, and a flap of cervical skin is developed on the left side. The left sternocleidomastoid muscle is retracted laterally and the strap muscles medially, so that the esophagus is readily exposed deep to the trachea and medial to the common carotid artery. A long segment is then mobilized, care being taken to preserve the vagus and recurrent laryngeal nerves. This mobilized segment is drawn anterolaterally and into a subcutaneous position through a muscle-splitting incision in the sternocleidomastoid muscle posterior to the external jugular vein. Two or three sutures are used to close the midportion of the defect in the muscle beneath the esophageal loop. Care must be taken to preserve a long, gentle arc of the esophagus in its new position (Figure). Two interrupted black silk sutures placed through the skin flap at the upper and lower borders of the subcutaneous esophagus will serve as invaluable guides to the precise locating of this segment during the second stage of the procedure. The skin is then closed with a continuous lock stitch of chromic absorbable surgical (gut) suture material, without drainage.

Three weeks later, when the primary wound is well healed, a circular area of skin is resected directly over the midportion of the superficial esophagus. The previously placed marking sutures and a large esophageal tube passed after the animal has been anesthetized will be helpful in precise locating of this area. The button of skin excised should be approximately 1 cm. in diameter. The esophageal musculature is readily identified, and a short transverse incision is made through it. The submucosa and mucosa are then opened, and a skin-to-mucosa anastomosis is completed with 8 or 10 interrupted fine silk sutures.

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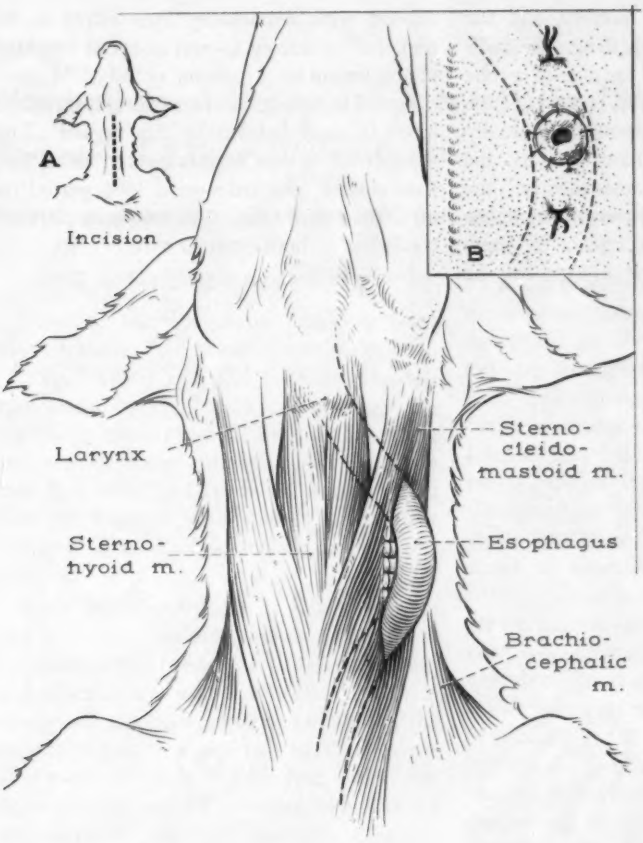

First stage of the procedure, with the esophageal loop now in a subcutaneous position. Note the gentle arc of the explanted cervical esophagus. *A*, the primary incision; *B*, completed esophageal stoma. The two guide sutures were placed during the first stage of the procedure.

Postoperative Care

After the first-stage procedure, subcutaneous hematomas developed in most of these dogs, despite careful hemostasis. One or two aspirations will facilitate healing, and probably are best done with the animal under the influence of general anesthesia, since the dogs will train more readily later if they are not abused. Between the first and the second stage of the procedure they are able to ingest liquids more readily than solids. We found condensed milk, supplemented with syrup, to be adequate while the animals were adjusting to the new position of their esophagus. After the second stage of the procedure some saliva and liquid dietary components are lost through the cervical stoma, and the dogs should be returned gradually to a solid diet. All the animals observed have had moderate difficulty in ingesting food after the first stage of the procedure, and they lost from 10% to 15% of their original body weight during the first three or four postoperative weeks. This loss was not progressive, and the weight of all animals became stabilized and an excellent state of nutrition was maintained, despite mild sustained difficulty in swallowing. The cervical stomas remained patent and usable for periods of three to six months, without the need of dilatation. Revision of the fistula with mucosa-to-skin anastomosis is readily accomplished, if required.

Conclusion

This type of surgical preparation can be used for the sampling of gastric contents,

for studies of esophageal motility, and for the administration of food, drugs, or radiopaque material. Repeated passage of a tube or catheter into the distal part of the esophagus or into the stomach is easily accomplished without discomfort to the unanesthetized animal; consequently, the undesirable factors of physical and emotional disturbance and the effects of anesthesia are eliminated. These dogs can be trained with remarkably little effort to lie undisturbed during several hours of repeated manipulation of a catheter or tube. Maintenance of a semidarkened room and complete quiet is most helpful in this regard. The distinct advantage of this procedure is that data can be collected over a long period on an animal that remains in excellent physical condition without especial care.

Section of Surgical Research, Mayo Clinic.

Formalinized Polyvinyl Alcohol (Ivalon) Sponge in Repair of Liver Wounds

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Introduction

Reported mortality rates resulting from liver trauma have varied widely: 90% (Krieg,[15] 1936) and 33.3% (Glas, Musselman, and Campbell,[7] 1955), hemorrhage being the primary cause of death in the great majority of these patients. This fact was well illustrated by Glas et al., who reported that the average whole-blood replacement required in their cases of liver trauma was 2000 cc.

With the above facts in mind, we felt that a better method for the control of hemorrhage and prevention of biliary fistulae and infection was needed if further improvements and results were to be enjoyed in the surgical resection and repair of liver tissue. The method which has evolved from this experimental project involves the use of formalinized polyvinyl alcohol (Ivalon) sponge as a hemostatic membrane.

History

With the increased interest in the resectional and reparative surgery of the liver, a short historical review seems applicable to a thorough appreciation of the developments in this field.

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From the Department of Surgery, University of Washington School of Medicine.

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U. S. Public Health Postdoctorate Research Fellow (Dr. Jones). Assistant Professor, Department of Surgery, University of Washington School of Medicine (Dr. Nyhus). Professor and Executive Officer, Department of Surgery, University of Washington School of Medicine (Dr. Harkins).

In 1874 Cousins[4] described the use of compression around the stump of tumor tissue by an elastic ligature followed by extraperitonealization. Escher,[5] in 1886, used and advocated the employment of cautery for tumor excision. Two years later Langenbuch[16] advocated lobectomy for lesions localized to one lobe of the liver. Clementi,[3] in 1890, described a two-stage removal of liver tissue. The first stage consisted of placing clamps across the liver tissue, the second stage being resection of the devitalized segment at a later date. However, it was not until 17 years after Cousins' first description that Lucke,[18] in 1891, performed the first recorded successful removal of a malignant lesion from the liver. Kousnetzoff and Pensky,[14] in 1896, described the use of preliminary hemostatic sutures and closure of the line of excision following resection. Anschütz,[1] in 1903, utilized gauze tamponade of the cut surface of the liver to control hemorrhage. McLean,[21] in 1929, advocated excision and hemostasis by electrocautery, while Reid,[25] in 1945, modified this method by placing preliminary hemostatic sutures through the liver tissue. The following investigators have recently made further advancements. Frantz et al.,[6] in 1944, described the use of oxidized cellulose. Bailey et al. (1945) and Jenkins (1947) described the use of gelatin sponge as a hemostatic agent, and Wangensteen,[28] in 1951, advocated temporary occlusion of the afferent blood supply to the liver during resection, pointing out that occlusion can be maintained for periods up to 33 minutes without damage to liver cells. These data have been confirmed recently by Goodrich et al.[8] (1956). Lortat-Jacob and Robert,[17]

in 1952; Pack et al.,[23,24] in 1953 and 1955, and others have modified, standardized, and perfected right lobectomy by anatomic dissection and sequential ligation of the afferent and efferent blood supply and biliary ducts of the right lobe of the liver. In 1954 Masters, Georgiade, Horton, and Pickrell[19] described the experimental use of split-thickness skin grafts in controlling hemorrhage from the cut-liver surface, and Serra and Brunschwig, in 1955, described the use of liquid nitrogen for hemostasis. Robinson and Butcher,[20] in 1956, described a new modified suture method for the control of hemorrhage.

As can be appreciated, there have been many valuable and noteworthy contributions to the surgery of the liver; however, even today, liver trauma continues to have a high mortality rate, and the technique of left hepatic lobectomy remains a difficult technical problem. The complications of late hemorrhage, biliary fistula, and infection are ever-present threats.

Method

Ten mongrel dogs of both sexes, weighing between 6 and 15 kg., were used in this study. The animals were given routine animal-quarters care with the addition of antibiotics (penicillin, 300,000 units, and streptomycin, 250 mg.) daily postoperatively for five days. Intravenous pentobarbital (Nembutal) sodium anesthesia was used for all operative procedures.

The 10 dogs were divided into two groups. Group I consisted of five dogs in which the left lobe of the liver was transected. The cut surface of the liver was covered with a tailored sheet of mildly compressed Ivalon (after the method described by Jesseph, Stevenson, and Harkins[25] in 1956). The Ivalon sheet was sutured to the circumference of the cut surface of the liver by a continuous over-and-over stitch of 000 black silk. Hemostasis during the liver resection and placement of the Ivalon was achieved by temporary occlusion of the afferent blood supply of the liver. The period of vascular occlusion was 5 to 10 minutes, and in no instance was there evidence of liver-cell damage. The average cut-surface area of liver covered by Ivalon was 12.1 sq. cm. (Fig. 1).

Fig. 1.—Operative procedure in Group I (liver resection with Ivalon repair).
On the left is the resected liver. On the right is the resected liver with the Ivalon patch partially sutured in place.

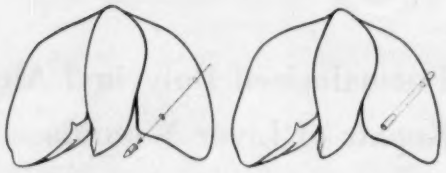

Fig. 2.—Operative procedure in Group II (bullet wound of liver with Ivalon repair).
On the left is the liver with a bullet wound. On the right a tube of Ivalon has been placed through the débrided bullet tract.

Group II consists of five dogs in which the centermost portion of the left lobe of the liver was shot one to three times with a 22-caliber air pistol at a muzzle distance of 2 ft. (60 cm.). The muzzle velocity ranged from 180 to 500 ft/sec. The resultant bullet tracts were debrided by means of a sharp cork bore. A tubular piece of Ivalon, just the size of the largest cork bore, was pulled through each bullet tract. The projecting ends of the Ivalon were excised level with the surface of the liver. The Ivalon was then sutured circumferentially to the surface of the liver with a continuous over-and-over stitch of 000 black silk (Fig. 2). In the instance of splintering of liver tissue extending out from the bullet tract, small pieces of the Ivalon sheeting were tailored and sutured into the fractures.

Following the original surgery, the dogs in the two groups were reoperated on three weeks, six weeks, four months, and eight months after the repair. At the time of reoperation gross observations were recorded and photographs taken. A representative biopsy specimen was also taken for microscopic study.

It should be noted that in each instance no attempt was made individually to ligate or coagulate vessels bleeding from the cut surface of the liver, nor was drainage ever used.

Results

In all of the animals there was rapid and permanent hemostasis of the cut or traumatized surfaces of the liver tissue. There were no instances of biliary fistula or excessive

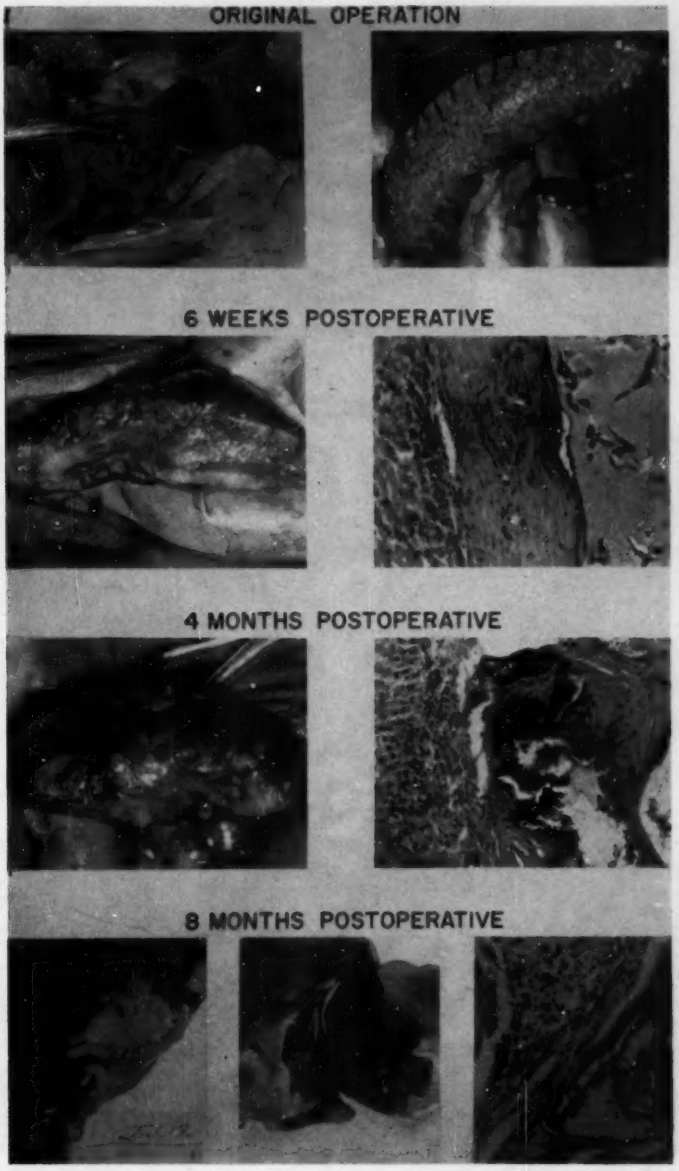

Fig. 3.—Gross and microscopic appearance of specimens in the animals with liver resection and Ivalon repair.

The upper two photographs illustrate, from left to right, the extent of resection and the completed Ivalon patch in position. The seven remaining photographs illustrate, from left to right, the gross and microscopic appearance six weeks, four months, and eight months following the repair. The middle photograph in the lower row is the cut gross specimen. Note the gross and microscopic evidence of the Ivalon acceptance by the liver, as depicted by the fibrous-tissue ingrowth of the Ivalon and the lack of cyst formation.

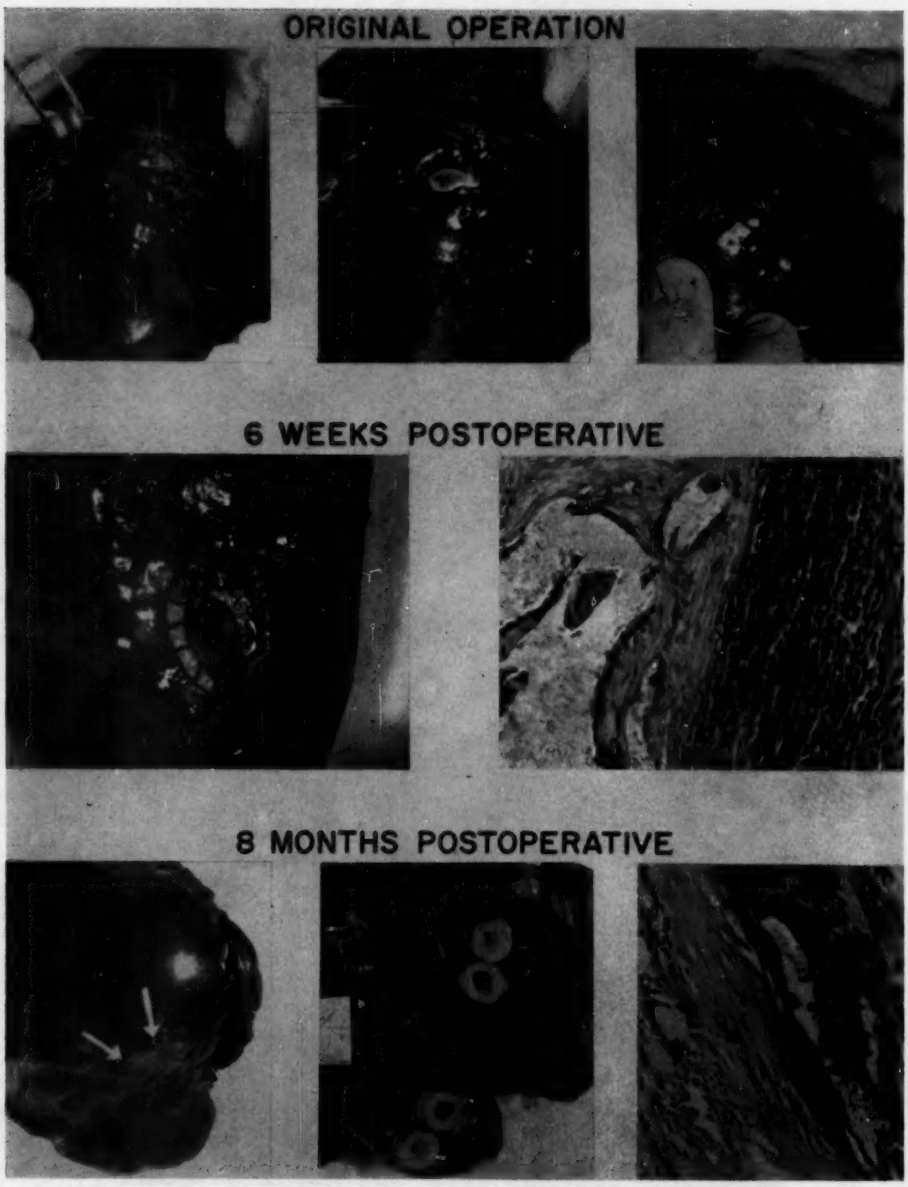

Fig. 4.—Gross and microscopic appearance of specimens in the animals with bullet wounds of the liver.

The upper photographs, from left to right, illustrate the bullet wound and bullet, the bullet wound tract after débridement with the surgeon's finger through the tract, and the completed Ivalon-tube repair. The two photographs in the middle row illustrate the gross and microscopic appearance of the liver wound and Ivalon tube six weeks after operation. The lower three photographs, from left to right, illustrate the gross, cross-sectional, and microscopic appearance of the wound and Ivalon eight months after operation. Note, again, the acceptance of the Ivalon.

formation of adhesions. There were no deaths among the 10 animals.

One animal in Group I developed a wound infection, which was contiguous with the liver repair. The dog, however, was alive and well at the end of the series (eight months), with complete resolution of the infection and excellent healing of the liver and its Ivalon patch.

Microscopic sections revealed that in all instances the Ivalon was fully accepted by the host tissue. There was fibrous-tissue ingrowth of the Ivalon without evidence of cyst formation, or other excessive foreign-body tissue reaction.

The results in the two groups were essentially identical except for the above-described complication. The Ivalon was fully accepted by the host tissues, and there were no instances of foreign-body reaction, sub-Ivalon hematoma formation, bile collection, or infection. There was also a minimal degree of scar-tissue contracture or surrounding gross tissue reaction. Typical results of these experiments are illustrated in Figures 3 and 4.

Comment

A new method for hemostasis has been devised for use in resectional and reparative surgery of the liver. The probable mechanism by which Ivalon provides its hemostatic action is by its physical structure, which is comparable to a micronet. Thrombin is deposited upon the Ivalon with the formation of a thrombin coagulum, which quickly fills the interstices of the membrane. It is through these same interstices that fibroblasts later invade the Ivalon. There were no deaths directly attributable to the procedures or to the Ivalon itself.

In all of the animals the liver wounds healed primarily, with only one instance of infection (which was an extension of an abdominal-wound infection).

There were no instances of hemorrhage or biliary fistula. Adhesions between the Ivalon and the surrounding tissues were no greater than adhesions between other organs and the abdominal wound. In each case microscopic sections revealed ingrowth of fibrous tissue without hematoma, Ivalon rejection, infection, or cyst formation, such as has been experienced with other hemostatic agents (Vanderhoof and Merendino,[30] 1949).

We believe that anatomic dissection and controlled hemostasis should be followed, as outlined by Pack and others. However, we also feel that the use of Ivalon is an important adjunct to the surgery of the liver.

Summary

A new method utilizing Ivalon (formalinized polyvinyl alcohol) sponge as a hemostatic agent in the repair of operative or traumatic liver wounds is described. No instances of hemorrhage, infection of the graft, or biliary fistulae were seen in this experimental study.

University of Washington School of Medicine (5).

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Formalinized Polyvinyl Alcohol (Ivalon) Sponge in Repair of Kidney Wounds

An Experimental Study

THOMAS W. JONES, M.D.; LLOYD M. NYHUS, M.D., and HENRY N. HARKINS, M.D., Seattle

Introduction

Partial nephrectomy has become a well-recognized and indicated procedure under certain circumstances. The use of this procedure, however, is not without its occasional complications of infection, hemorrhage, or urinary fistula. With these complications in mind, we felt that an experimental study should be carried out to evaluate formalinized polyvinyl alcohol (Ivalon) as an adjunct to this type of excisional therapy.

History

It is of interest in relation to this experimental study to review the evolution and development of heminephrectomy, for the fundamental idea is certainly not new.

The first recorded total nephrectomy was performed by Simons [4] in 1869. Czerny,[1] in 1887, performed one of the first partial nephrectomies. This latter procedure, however, fell into disrepute during the early 1900's, presumably owing to the high mortality and morbidity rates associated with it. Over the past 35 years there has been renewed interest in this procedure, due to efforts of Mathe et al. (1950) and others. Today, like liver resection, it is a recognized and advocated procedure when properly indicated.

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From the Department of Surgery, University of Washington School of Medicine.

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Method

Ten mongrel dogs of both sexes, weighing between 6 and 15 kg., were used in this study. The animals were given routine animal-quarters care with the addition of antibiotics (penicillin, 300,000 units, and streptomycin, 250 mg.) daily postoperatively for five days.

Intravenous pentobarbital (Nembutal) sodium anesthesia was used for all operative procedures.

The 10 dogs were divided into two groups.

Group I included five dogs in which the right kidney was transected and likewise covered with a compressed sheet of Ivalon. The Ivalon, as in the liver resection, was sutured to the circumference of the cut edge of the kidney by a continuous over-and-over stitch of 000 black silk. Hemostasis during the resection and placement of the Ivalon was achieved by temporary clamping of the vascular pedicle. The average cut-surface area requiring Ivalon coverage was 6.3 sq. cm. The duration of vascular occlusion was 5-10 minutes (Fig. 1).

Group II consisted of five dogs in which the upper pole of the right kidney was shot one to three times with a 22-caliber air pistol at a muzzle distance of 2 ft. (60 cm.). The muzzle velocity ranged from 180 to 500 ft/sec. The resultant bullet tracts were debrided by means of a sharp cork bore. A tubular piece of Ivalon, just the size of

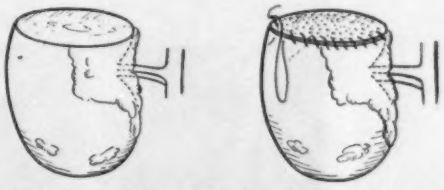


Fig. 1.—Operative procedure in Group I (kidney resection with Ivalon repair).

On the left is the resected kidney. On the right is the resected kidney with the Ivalon partially sutured in place.

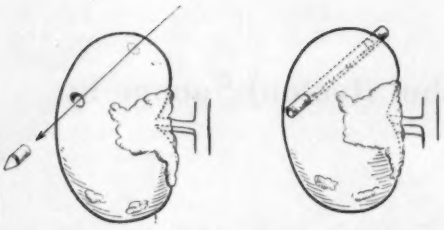


Fig. 2.—Operative procedure in Group II (bullet wound of kidney with Ivalon repair).

On the left is the kidney with a bullet wound. On the right a tube of Ivalon has been placed through the débrided bullet tract.

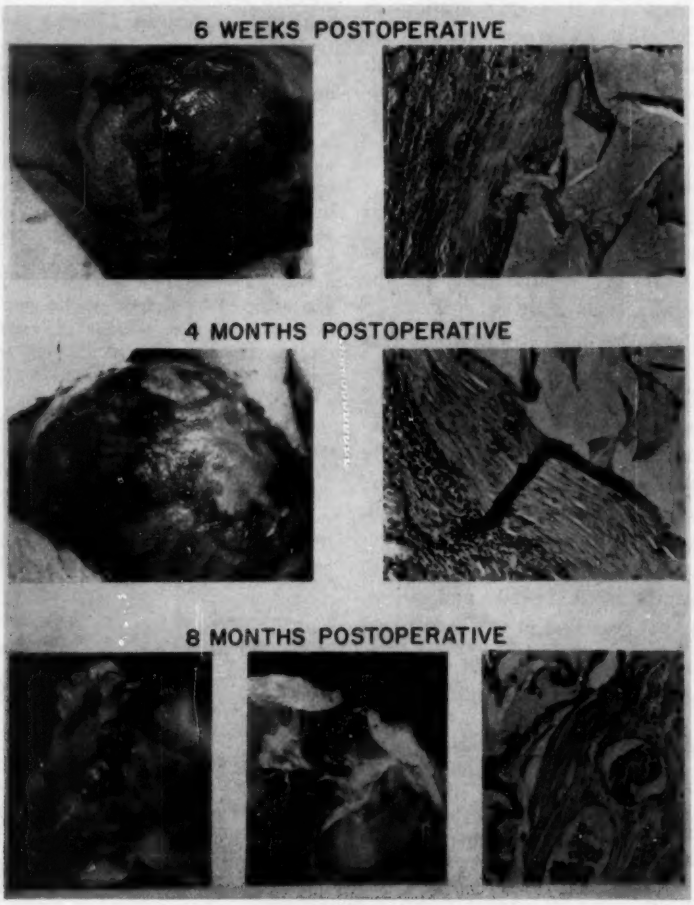
the largest cork bore, was pulled through each bullet tract. The projecting ends of the Ivalon were excised level with the surface of the kidney. The Ivalon was then sutured circumferentially to the surface of the kidney with a continuous over-and-over stitch of 000 black silk (Fig. 2).

Following the original operation, the dogs in the two groups were reoperated on at three weeks, six weeks, four months, and eight months after repair. At the time of reoperation gross observations were recorded and photographs taken. A representative biopsy specimen was also taken for microscopic study.

Fig. 3.—Gross and microscopic appearance of specimens in the animals with kidney resection and Ivalon repair.

The upper row of photographs illustrates the appearance six weeks, the middle row four months, and the lower row eight months, following the repair. The middle photograph in the lower row is the cut gross specimen.

Note again in these representative specimens the gross and microscopic evidence of the Ivalon acceptance by the kidney, as depicted in this instance by the fibrous-tissue ingrowth of the Ivalon and the lack of cyst formation.



It should be noted that in each instance, no attempt was made individually to ligate or coagulate vessels bleeding from the cut surface of the kidney, nor was drainage ever used.

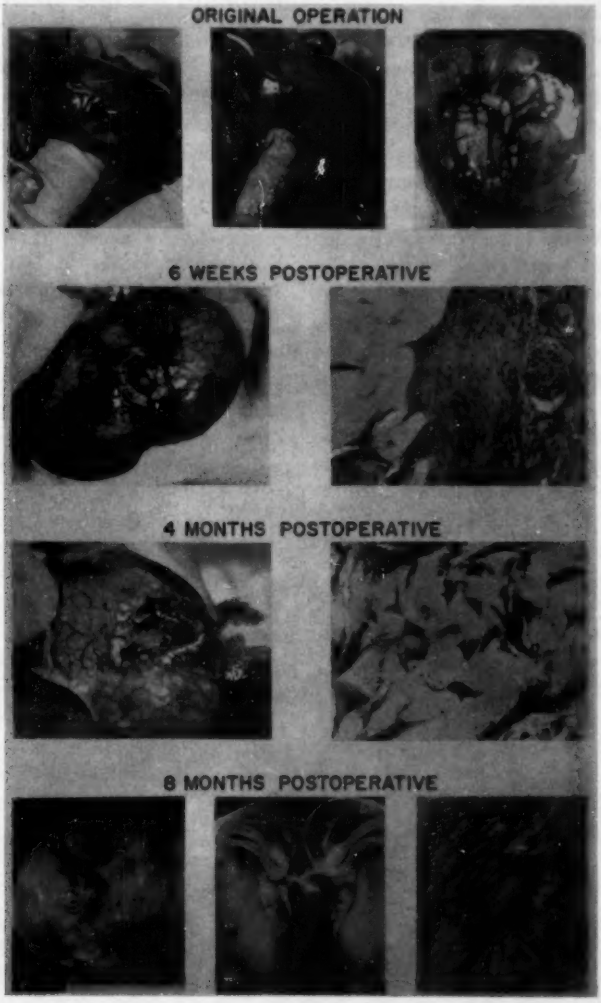
Results

In all of the animals there was rapid and permanent hemostasis of the cut or traumatized surfaces of the kidney tissue. There were no instances of urinary fistulae or infection. There were two deaths; one dog died of distemper, and the second died of acute gastric distention. Both the kidney specimens in these two dogs were in good

Fig. 4.—Gross and microscopic appearance of specimens in the animals with bullet wounds of the kidney.

The upper photographs, from left to right, illustrate the size of the bullet tract and bullet, the Ivalon tube in place, and the completed Ivalon-tube repair. The second row of photographs illustrate the gross and microscopic appearance of the kidney wound and Ivalon tube six weeks following operation. The third row of photographs demonstrate the same four months after operation. The lower row of photographs, from left to right, illustrate the gross, cross-sectional, and microscopic appearance of the kidney wound and Ivalon eight months after operation.

Note again the acceptance of the Ivalon by the kidney. The lower photograph of the cross section of the kidney demonstrates that urine was actually being filtered through the Ivalon, but without the formation of an external urinary fistula.



condition, without evidence of hemorrhage, urinary fistulae, or infection.

Microscopic sections revealed that in all instances the Ivalon was fully accepted by the host tissue. There was fibrous-tissue ingrowth of the Ivalon without evidence of cyst formation or other excessive foreign-body tissue reaction. Typical results of these experiments are illustrated in Figures 3 and 4.

Comment

An experimental method for hemostasis has been devised for the use in resectional and reparative surgery of the kidney. The probable mechanism by which Ivalon provides its hemostatic action is by its physical structure, which is comparable to a micronet. Thrombin is deposited upon the Ivalon with the formation of a thrombin coagulum, which quickly fills the interstices of the membrane. It is through these same interstices that fibroblasts later invade the Ivalon.

In all instances the kidney wounds healed primarily without infection.

There were no instances of hemorrhage or urinary fistulae. In each case microscopic sections revealed ingrowth of fibrous tissue without hematoma, Ivalon rejection, or infection.

A word of warning should be given, however, before any clinical application of this experimental study be made. Hinman and Babcock[3] (1949), in a series of experiments, demonstrated that the use of absorbable hemostatic agents in contaminated nephrotomy wounds produced a very high (99%) incidence of abscess formation. Thus, any foreign body used in clinical nephrotomy wounds should be used sparingly and with considerable discretion.

Summary

A new experimental method is described utilizing Ivalon (formalinized polyvinyl alcohol sponge) as a hemostatic agent in the repair of operative or traumatic kidney wounds. No instances of hemorrhage, infection, or urinary fistulae were noted in this experimental study.

University of Washington School of Medicine (5).

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Limitations of Synthetic Fabrics as Peritoneal Substitutes

JAMES LEMONS, M.D., and HAROLD LAUFMAN, Ph.D., M.D., Chicago

The use of foreign substances to reinforce hernial repairs is almost commonplace today. Most popular among these materials are mesh screens of tantalum or steel and cloths made of synthetic yarns, such as Fortisan, nylon, and Dacron. In addition to their immediate function as structural supports, these substances further strengthen the closure by becoming enmeshed in fibrous tissue as time goes along. It is well known that no foreign substance is as well tolerated as the host's own tissues. Adequate surgical repair of some defects, however, is possible only with the use of substitute materials. Occasionally in clinical surgery it is necessary for the patch of foreign substance to come in direct contact with the serosal surfaces of underlying bowel, as, for example, after extensive resection of the diaphragm, pelvic peritoneum, or all abdominal-wall layers for malignancy, or when mural structures cannot be approximated for other reasons. No material has yet been found to substitute for peritoneum. Since foreign substances tend to stimulate the formation of fibrous tissue, it was of some interest to investigate their adhesion-forming potential when exposed to the peritoneal cavity.

Islami and Pack [1] have recently reported their disappointing results with nylon in the surfacing of resected liver wounds. The nylon usually caused dense adhesions to neighboring structures. The cloth was found wrinkled and not attached to its original moorings. Sanford, Riley, and Sauvage [2] evaluated Orlon fabric in the repair of defects in the abdominal wall of rabbits. They found that following contamination the fabric leads to chronic infection, with the frequent formation of abscesses and draining sinuses. On the other hand, tantalum mesh did not predispose to the development of these complications following standardized contamination of a wound.

Harrison, Swanson, and Lincoln [3] compared the tissue reactions to plastic materials by placing such substances as nylon, Dacron, Orlon, Teflon, compressed and polyvinyl (Ivalon) sponge in the subcutaneous tissue of dogs. They found that although the host response to all these substances is minimal, there was some difference in tissue reactivity among them. Teflon produced the lowest degree of either acute or chronic inflammatory reaction, and in order of ascendancy, Orlon, polyvinyl sponge, Dacron, and nylon.

There is some illogic in expecting a foreign material to provide a smooth-working surface in the peritoneum at the same time that it stimulates fibrous-tissue formation in the abdominal wall and elsewhere; yet the degree of local peritoneal reaction is unknown, and investigation appears justified.

Because some reactivity would seem desirable for fibrous-tissue ingrowth in the repair of a hernial defect, nylon and Dacron appeared to us to be the materials of choice for experimentation. In order that the surface exposed to the peritoneum cause as little fibroplastic reaction as possible, we decided that an extremely fine texture of these materials should be employed. In addition to nylon and Dacron, we used fine-mesh Fortisan as a third substance for comparison on the basis of its lower index of wettability.

Our experiments in 28 dogs consisted of placing a patch of these three fine-mesh

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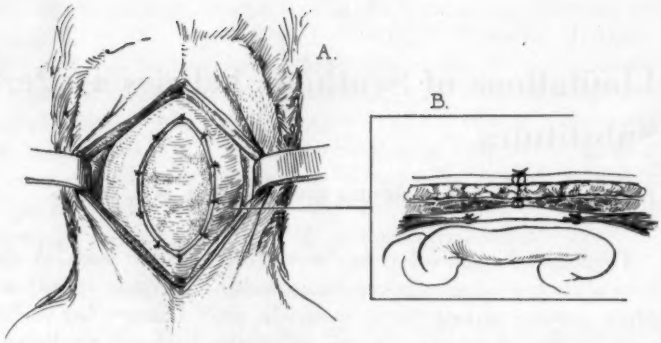

Fig. 1.—*A*, placement of fabric patch in anterior abdominal wall after excision of peritoneum and endoabdominal fascia. *B*, cross-sectional diagram showing bowel in contact with fabric, internally, and potential dead space between fabric and muscular layers, externally.

Fig. 2.—Adhesion formation at six weeks between omentum, bowel, and inner surface of nylon implant in anterior abdominal wall.

Fig. 3.—Minimal adhesion formation at eight weeks between omentum and inner surface of Dacron implant in anterior abdominal wall. Note area of fabric covered by glistening layer of peritoneum without adhesions in upper part of photograph.

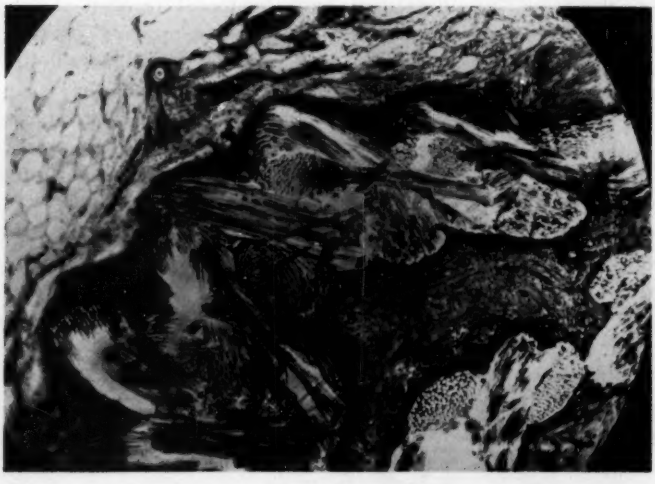

Fig. 4. — Photomicrograph of Dacron fabric insert, showing dense infiltration of fabric by fibrous tissue. At upper left can be seen free surface covered by mesothelial cells.

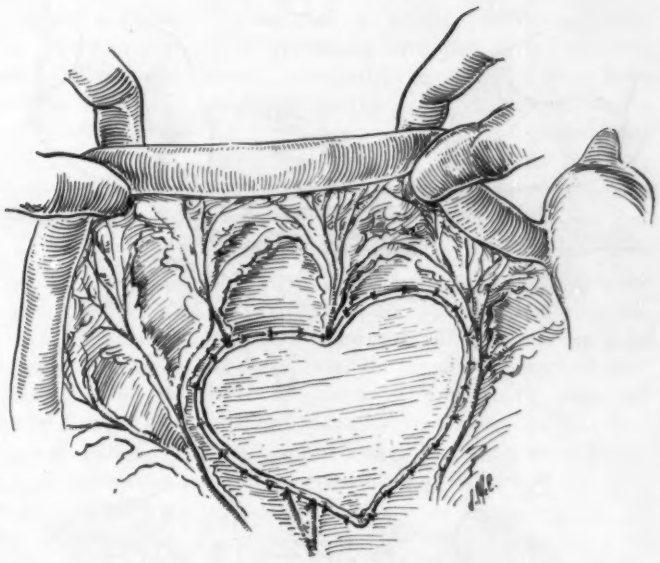

Fig. 5.—Placement of fabric patch into mesenteric defect.

cloths in each of three dispositions: (1) to replace an excised area of parietal peritoneum of the anterior abdominal wall, (2) to fill a defect in the mesentery, and (3) to cover denuded areas of serosa on the ileum.

Materials

(*a*) A regenerated cellulose yarn, Fortisan fabric.* Denier per filament of the order of 0.75.

* Produced by highly orienting the internal filament structure of a cellulose acetate or other cellulose ester yarn, and saponifying. Supplied by Celanese Corporation of America, 300 W. Adams St., Chicago.

Fig. 6.—Appearance of Fortisan mesenteric patch at four weeks. Most of patch is covered by densely adherent omental fat and bowel. Adherent bowel has been removed at left to reveal area of wrinkled and stiff fabric.

(*b*) Sheer nylon fabric† of 100% nylon, a condensation product from which water is expelled upon polymerization.

(*c*) Sheer Dacron fabric† of 100% Dacron, a polyester, polyethylene glycol terephthalate, also a product of condensation reaction in which water is expelled.

Review of the published physical characteristics of these fabrics indicates that the cellulose yarn is the least wettable of the three, and nylon the most. The weights and weaves of all three substances were approximately equal. All extraneous matter was removed from the fabrics by the supplier.

Methods and Results

Adult mongrel dogs were anesthetized with intravenous thiopental (Pentothal) sodium. Sterile and aseptic techniques were used throughout, and penicillin was administered postoperatively to all dogs. Reoperation was carried out two to eight weeks after implantation. The area was examined grossly; photographs were taken, and the area was then excised and placed in formalin solution in preparation for microscopic examination.

† Supplied by the Bauer & Black Division of the Kendall Company, Research Department, 2500 S. Dearborn St., Chicago. Both nylon and Dacron are designated generally as Samples 56 RD-2 by the manufacturer.

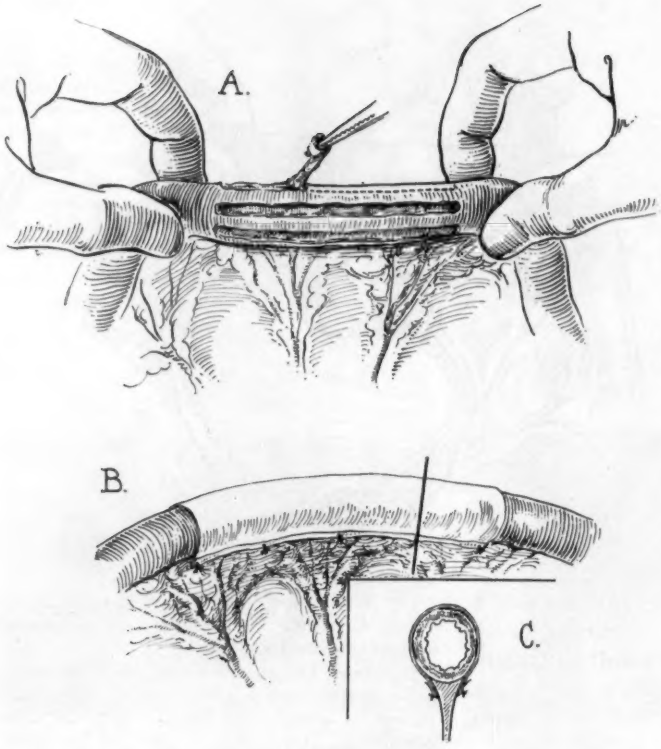

Fig. 7.—*A*, method of stripping ileal serosa; *B*, stripped segment wrapped with fabric; *C*, cross-sectional view after wrapping.

Anterior Abdominal-Wall Defect (Fifteen Dogs).—An area of peritoneum and endoabdominal fascia extending approximately 3 cm. on either side of a midline abdominal incision was excised. The excised tissue left a defect measuring 4×6 cm., into which a patch of fabric was sutured with cotton sutures. The edges of the material were piped and the knots so placed that no raw edges or suture ends faced the peritoneal cavity. Anterior fascia and skin were closed by interrupted sutures over the patch.

Fig. 8.—Appearance of Dacron-wrapped ileum at six weeks. Although a large portion of fabric is covered by glistening layer of mesothelium, fabric is wrinkled and rather stiff. Neighboring bowel and mesentery are markedly adherent.

Dacron was used in nine dogs; Fortisan, in three, and nylon, in three. Despite the aseptic precautions, infection (abscess formation, sinus formation, granuloma) was grossly evident in three dogs with Dacron, two dogs with Fortisan, and one dog with nylon. It appeared that all the substances served as irritants and enhanced the development of infection about them.

Of the five clean Dacron specimens, three showed minimal adhesions to omentum and bowel; one revealed somewhat more proliferation of adhesions, and one had very dense fibroplastic adhesions to intraperitoneal structures. Of the three infected Dacron specimens, adhesions on the peritoneal side were marked in two and moderate in one.

The nylon implants all showed a rather heavy adhesive response to omentum and bowel. One of the nylon specimens obtained at three weeks showed somewhat fewer adhesions, but more than the better Dacron specimens.

All of the Fortisan implants into the anterior defect were densely adherent to intraperitoneal structures.

Microscopically, the Dacron specimens were of some interest in that the adhesion-free portions became covered by a layer of peritoneal mesothelium, while the interstices were infiltrated with fibroblasts. The microscopic appearance of both the nylon and the Fortisan specimens showed extremely dense fibroblastic infiltration. Polymorphonuclear-cell infiltration was proportionate to the degree of grossly visible infection.

Mesenteric Defect (Nine Dogs).—A defect measuring approximately 10×12 cm. was made in the mesentery of the distal ileum by severing several mesenteric vessels in the second arcade, care being taken not to endanger the circulation of the bowel. A patch of fabric was sutured into the defect with interrupted cotton sutures.

Fortisan was used in five dogs with mesenteric defects, nylon in three, and Dacron in one. In each instance, regardless of the material used, the patch was found to be wrinkled, somewhat stiffer than when it was inserted, and invariably adherent to neighboring bowel and mesentery. Foreign-body reaction was thus evident with all three materials when they were placed in a motile area, such as the mesentery. It was a difficult problem in grading to determine which of the three materials produced the least reaction, and it was concluded that none of the substances could serve as a satisfactory patch for a mesenteric defect.

Serosal Stripping and Wrapping (Four Dogs).—Three ⅛ in. strips of serosa, measuring 4 cm. in length, were denuded from the sides and antimesenteric border of the ileum. The area was then wrapped with fabric, which was sutured in place with interrupted fine cotton sutures.

Two dogs, in addition to the series of four specimens wrapped with material, served as controls insofar as they were subjected to the stripping of the serosa but received no wrapping of foreign material. These controls were made in order to compare the degree of adhesion formation of the untreated, raw muscularis with that of the wrapped specimens.

Of the two Dacron, one nylon, and one Fortisan specimens, all exhibited more adhesions to omentum and neighboring loops of bowel than did the two unwrapped, control specimens. Furthermore, all the wrapped segments were somewhat distorted, narrowed, or kinked by the rather stiffened, wrinkled material around them.

Summary

Our attempts to utilize fine-mesh, lightweight synthetic foreign substances as peritoneal replacement indicated that the substances tested are unsatisfactory as substitutes for the peritoneal membrane because of the marked fibroplastic response they engender. Dacron, in three of eight attempts, appeared to become covered by a mesothelial layer with an acceptable minimum of adhesions when implanted as a substitute for anterior parietal peritoneum. Perhaps further investigation with this substance is justified on this basis. However, our experiences have led us to believe that certain limitations exist in the use of any foreign substance as a peritoneal substitute.

If the material is very tightly woven, it may prevent the passage of tissue cells and nutrients, and thus serve as a catch basin for fluids and a nidus of infection. If it is more loosely woven, or is of extremely thin texture, the ingrowth of fibroblastic elements is excellent, but, by the same token, the adhesion-forming potential between the tissues on one side of the material and those on the other is high. The material itself, no matter how inert, serves as a potentiating irritant to the reaction of the tissues. A low index of wettability is apparently of no

significance in reducing the degree of foreign-body reaction in the peritoneal cavity.

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Carcinoma of the Parathyroid

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The metabolic status of the patient previously reported [1] was studied periodically, and during the summer of 1957 hypercalcemia and hypophosphatemia developed without subjective symptoms. It was felt that the malignancy had recurred, and operation was advised; but the patient postponed surgical intervention until Dec. 3, 1957, by which time a small nodule had become palpable in the left side of the neck. At the time of exploration recurrent tumor was found locally in the thyroid fossa, and there was lymphatic spread in the superior mediastinum. In addition, there was a metastatic nodule in the sternothyroid muscle. The sternothyroid and sternohyoid muscles were completely excised, and all gross tumor was excised en bloc. In the immediate postoperative period this patient again had clinical pancreatitis and an associated elevated serum amylase concentration. At the present time the patient is receiving deep x-ray therapy to the neck and upper mediastinum.

Veterans' Administration Hospital (31).

Submitted for publication Dec. 31, 1957.

An addendum to the article by the authors published in the January issue.

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Multiple Arteriosclerotic Aneurysms

Report of Case of Successful Surgical Removal

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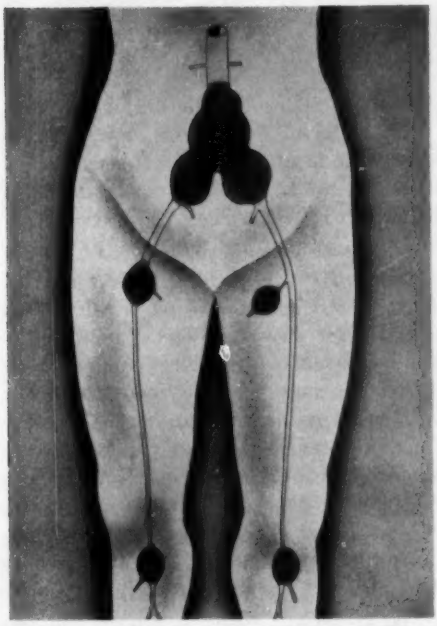

Fig. 1.—Schematic drawing of the five aneurysms.

The reported incidence of multiple arteriosclerotic aneurysms varies from zero to 30%, but the average is probably in the neighborhood of 10%.[1-22] The literature reveals little comment regarding treatment of multiple arteriosclerotic aneurysms [6] in spite of the fact that it is now an accepted fact that single aneurysms can be satisfactorily treated by excision and grafting.[23] The unusual case to be reported presented five separate definite aneurysms (Fig. 1), bringing up several interesting questions: 1. If a patient has multiple arteriosclerotic aneurysms, is the arterial disease too generalized and severe for the employment of surgical treatment? 2. What are the dangers of allergic response to successive arterial homografts? 3. What is the significance of the anatomical pattern of arteriosclerotic aneurysms?

Submitted for publication Dec. 9, 1957.

From the General Surgical Service, Medical Teaching Group Hospital, Veterans' Administration Hospital (15).

Brief Clinical Summary

History.—This 59-year-old white man was admitted to the Medical Teaching Group of the Veterans' Administration Hospital (July 2, 1956) with the chief complaint of a painful mass in the right inguinal region that had been slowly enlarging over a period of two years.

Physical Examination.—The temperature, pulse, and respiration were normal; the blood pressure was 130/90. General inspection revealed a well-developed, well-nourished white man who did not appear acutely or chronically ill. Routine examination revealed a mass in the right inguinal area, approximately 8 cm. in diameter, that was pulsatile in nature. Further examination revealed similar pulsatile masses in the left inguinal region in the abdominal aorta and in both popliteal fossae. The remainder of physical examination was essentially negative.

Routine Laboratory Data.—These were not remarkable. Serology tests for syphilis were negative.

Diagnosis.—Bilateral femoral, bilateral popliteal, and abdominal aortic aneurysms.

Course in Hospital.—Aortography was performed to establish the limits of the abdominal aortic aneurysm, which was found to be typical, arising approximately 2 in. (5 cm.) below the renal arteries and extending into both common iliac arteries, the dilatation ending abruptly at the bifurcation of the common iliac arteries. The aortogram faintly visualized the bilateral femoral aneurysms. Visualization of the popliteal aneurysms was not considered necessary. At five successive operations, the five aneurysms were excised, and ethylene-oxide-treated freeze-dry arterial homografts were placed, in the following order: right common femoral (July 9), right popliteal (Aug. 2), left popliteal

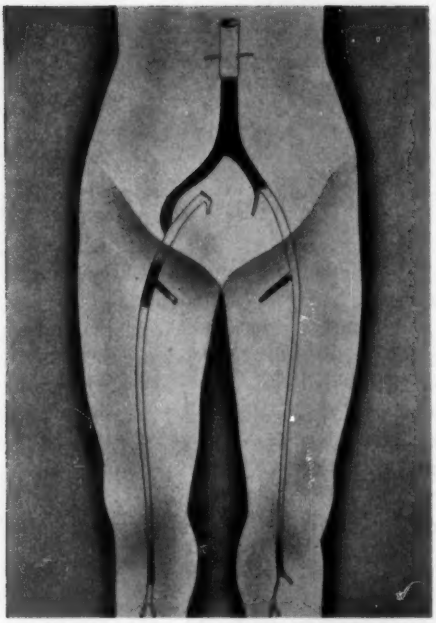

Fig. 2.—Schematic drawing following surgery with implantation of five arterial homografts.

(Aug. 14), abdominal aortic (Aug. 28), and left deep femoral (Sept. 24) (Fig. 2). Right lumbar sympathectomy preceded excision of the right popliteal aneurysm, but did not seem necessary and was not repeated on the left side. The patient's arteries showed evidence of generalized dilatation and intimal thickening. The five aneurysms were well localized, with the following diameters: right common femoral, 6.5 cm.; right popliteal, 3.5 cm.; left popliteal, 3.0 cm.; abdominal aortic, 9 cm. (attached iliac, 5.0 cm.), and left deep femoral, 4.0 cm. The pathologist reported the etiology of the aneurysms to be arteriosclerosis. Postoperatively, the patient was given prophylactic antibiotics, and early ambulation was instituted. Recovery was uneventful following each of the five operations.

Follow-Up Examination 14 Months After Last Operation.—The patient stated that after discharge from the hospital he was able to return to work as a foreman for a construction company, which required moderate physical activity. The patient's only complaint was "tiredness" in his legs after standing for long periods of time. Physical examination revealed all grafts to be functioning satisfactorily, without evidence of dilatation.

Comment.—Almost all physicians agree with the surgical treatment of the symptomatic right common femoral aneurysm, but many still hesitate to recommend surgery for asymptomatic aneurysms. The danger that rupture or thrombosis will be the first symptom of an aneurysm is well known,[11,19] and the satisfactory outcome in this case speaks well for surgical excision and grafting of all aneurysms.

Careful forethought was given to the order in which the aneurysms should be removed. In retrospect, the sequence was not important. Lumbar sympathectomy preceding excision of popliteal aneurysm does not seem to be necessary if the arterial circulation can be reestablished by a graft. If the aneurysm involves the popliteal bifurcation, then insertion of a graft is technically impossible and lumbar sympathectomy is definitely of great value.[24]

A previous patient had received a second aortic homograft and had developed a severe generalized dermatitis on the eighth postoperative day. Six weeks later the patient died suddenly. The possibility of allergic reaction to the second homograft was considered but could not be proved. Since the present case required five successive homografts at approximately two-week intervals, the possibility of allergic response was considered. The precaution was taken to use a different donor for each graft, which should lessen the chance of allergic reaction.

The abdominal aortic aneurysm and the two common iliac artery aneurysms were counted as one, since they were adjacent and were replaced with one arterial graft. It is interesting to note that the aneurysms were symmetrical except for one, the left deep femoral aneurysm. With this exception, the other six aneurysms followed the general pattern commonly observed with arteriosclerotic aneurysms by occurring immediately proximal to a bifurcation or a major branch of an artery. Weakness of the arterial wall is the usual explanation offered for the causation of arteriosclerotic aneurysms,[25] but this does not explain why a great number occur immediately above a bifurcation or major branch. After the hemodynamic explanation of poststenotic dilatation by Holman,[26] which had so long baffled the

medical world,[27] it seems possible that the predilection of arteriosclerotic aneurysm for these sites may be explained in somewhat the same manner. However, Holman[28] attempted to explain the average arteriosclerotic aneurysm upon the basis of this poststenotic dilatation, which certainly is not the underlying principle in the majority of the arteriosclerotic aneurysms, because this proximal stenosis is only rarely seen.[9] Krafka,[29] studying stress in arteries, found that the lateral tension equals the longitudinal tension when the arteries are elastic, but when the arteries are rigid, due to disease, the lateral tension is twice the longitudinal tension and may account for aneurysm formation.

Blakemore[30] considered that aneurysm formation is related to the elongation of the artery usually accompanying the aneurysm, with resultant change in direction, causing "water-hammer pulse." Krafka's and Blakemore's explanation of the etiology of arteriosclerotic aneurysms has not been widely accepted. That arteriosclerotic aneurysms usually occur in larger arteries can be explained by Laplace's law (tension = radius × pressure).[31] Laplace's law refers to static fluid and does not reflect the effect of blood motion. Bernoulli's principle refers to fluids in motion, stating that the greater the velocity the less the lateral tension. Both Laplace's law and Bernoulli's principle play a part in explaining the hemodynamics of blood flow, but as yet they have not been combined into one equation. Even more difficult to measure is the hemodynamic effects of the aortic bifurcation. It is possible that the change of direction of blood flow, the break-up of the laminated blood stream, and the changes of blood velocity at the bifurcation could release kinetic energy, increasing the lateral tension upon the arterial wall. Since no mathematical equation exists to calculate tension in such a system,[32] a laboratory model is presently being built to test this theory by direct measurements.

Summary

A report of a patient who successfully survived surgical removal of five separate aneurysms is made.

The locations of the aneurysms include the abdominal aorta and the femoral and popliteal arteries bilaterally.

Certain comments concerning the mechanics of the formation of aneurysms are submitted.

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Osteotomy of the Spine for Correction of Fixed Flexion Deformity

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Osteotomy of the spine for correction of fixed flexion deformity has proved to be a very satisfactory procedure.

The disease of ankylosing spondylitis (rheumatoid arthritis of the spine; Marie-Strümpell arthritis) presents different phases of treatment. In the early stage medical and irradiation therapy, plus the prevention of deformity, is indicated. The second phase, with flexion deformity, but in which there is not complete bony fusion of articular facets and longitudinal ligaments, may be corrected or controlled by hyperextension frames, casts, and braces. In the final stage of the disease, however, in which bony ankylosis exists with severe fixed flexion deformity of the spine, osteotomy is indicated. This offers for the patient dramatic improvement not only in appearance but in general well-being and affords an important psychological lift.

Smith-Petersen, Larson, and Aufranc,[13] in 1945, first described osteotomy of the spine and reported results in six cases. Since that report, La Chapelle,[9] Briggs et al.,[2] Herbert,[7,8] Thompson and Ingersoll,[15] Nunziata,[12] Stuart and Rose,[14] Chapchal,[3] Law,[10] Adams,[1] Helfet,[6] Wiberg,[16] Fortier and Hébert,[5] and del Torto,[4] among others, have reported successful cases.

The main indication for surgery is a severe ankylosed flexion deformity of the spine not correctible by conservative measures, and in which the patient has difficulty in seeing ahead. Severe fixed flexion deformity of the hips, of either a fibrous or a bony nature, in addition to the spinal deformity, usually is a contraindication. The hip problem and possible correction thereof should be considered first. I rejected two patients for spinal osteotomy, one in the sixth and one in the seventh decade of life, with pronounced deformities of hips and spine, as both had accommodated well physically, and especially so socially, to their respective deformities. Other considerations for spinal surgery are improving the function of thoracic and abdominal structures, allowing the patient to return to a gainful occupation, and making him more acceptable in general society. One patient in our series had been refused a baby by an adoption agency prior to his surgery but after surgery, and with his improved appearance, was approved, and he and his wife were awarded a baby.

The optimum site of osteotomy is lumbar for the thoracolumbar deformity. Ankylosis of costovertebral joints makes correction in the thoracic spine more difficult. Smith-Petersen and co-workers reported one case, but without objective improvement. Herbert reported seven cases with osteotomy done in the lower thoracic spine and one with correction in the upper thoracic spine; however, the amount of correction was not described.

Cervical spinal osteotomy is rarely indicated. Mason, Cozen, and Adelstein reported a successful case in 1953, and Herbert reported three cases.

The operative technique was well described by Smith-Petersen and co-workers. Painstaking care in these details is important. The wedge of bone to be removed has

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From the Division of Orthopedic Surgery of the U. S. Veterans' Hospital, West Los Angeles, and the University of California School of Medicine at Los Angeles.

its base posterior; the apex lies at the anterior margins of the intervertebral foramina, and the fulcrum of corrective motion is at the posterior margins of adjacent vertebrae. One or two osteotomies may be done, and the angle of correction to be obtained will correspond in general to the angle of the wedge or wedges. Wilson and Turkell [17] and del Torto [4] have described variations in operative technique, but these, in my opinion, have made no significant improvement in the original technique.

A prone position for surgery is most commonly used, although Adams described the steps and benefits with the patient in a lateral position. He also described a special apparatus for obtaining correction after the osteotomy. Fortier and Hébert have also used the Adams technique.

Careful surgery with control of bleeding facilitates the operation. The dura is apt to be thickened and adherent to the overlying ossified ligamentum flavum and may be punctured even with much care in stripping it away. This of itself is not too important except that the flow of spinal fluid into the wound creates an additional operative problem.

Unroofing the foramen may be easy, but often the inflammatory process causing the articular destruction has led to fibrous and bony proliferation, with encroachment on the foramen. This adds to the technical difficulties, and much care is necessary not to traumatize nerve roots.

Correction of the deformity after completion of the wedge or wedges consists in raising the head and foot of the table with approximation of the opposing oblique surfaces of the osteotomy. I have used careful manual pressure at the osteotomy site to assist in the closure of the posterior gap. An audible (and somewhat sickening) snap may be heard during the correction, which indicates separation of anterior ligaments. The locking of the osteotomized surfaces and the integrity of the posterior longitudinal ligament ensure against any serious displacement. Briggs et al. used a Wilson spine plate to stabilize the spine after correction. A delay of three months in doing the spinal fusion was advocated by Stuart and Rose. This does not seem necessary—however as the spinal fusion technique of Smith-Petersen et al., can immediately follow the osteotomy and without evident additional operative risk to the patient. Division of the anterior longitudinal ligament through a separate incision, as described by La Chapelle and Herbert, would appear rarely necessary and was not, even in rather pronounced anterior ossification, as in Case 4, presented herein.

Following correction and closure a posterior plaster shell, extending to the knees, is made. The next day an anterior shell is made. The patient should be turned often to prevent pressure sores. One such complication occurred in this series, although it did not prove to be serious. Adams reported such a complication with the development of a large anterior spinal abscess and death 10 weeks after osteotomy. Paralytic ileus is a frequent complication but with the usual measures can be well controlled.

The patient is placed in a body cast, extending to at least one knee, after two weeks. Bed rest is continued for a total of two months, followed by a back brace and gradual ambulation. Careful observation, both of the patient and of roentgenograms, is necessary to prevent loss of correction, which is apt to occur and did in one of our cases between six and nine months after operation. Reasons for loss of correction are insufficient immobilization from a poor-fitting support, failure of the patient to wear his brace as prescribed, or his failure to return for follow-up observation.

It is estimated that at least one year is necessary for solid bony union sufficient to prevent loss of correction, and during this time support should be worn. Caution against overcorrection at surgery has been mentioned in the literature, but I have not encountered it and know of no such case. In the event that this should occur at surgery, a gradual correction by attention to postoperative support would most probably control this.

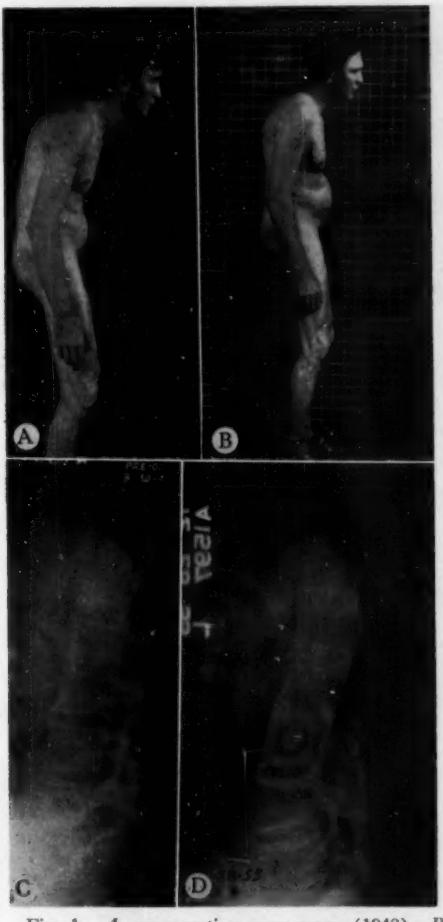

Fig. 1.—*A*, preoperative appearance (1948); *B*, postoperative appearance (1956). *C*, preoperative roentgenograms (1948); *D*, postoperative roentgenograms (1955).

Report of Cases

CASE 1.—A man, aged 32, had had pain and increasing deformity of his spine for seven years and concurrently had had several attacks of renal calculi and iridocyclitis. The usual blood, urine, and serology tests revealed nothing unusual. There was marked limitation of head and neck motions. Osteotomy at two levels, L2-L3 and L3-L4, was performed Aug. 31, 1948.

Figure 1*A* and *B* show the patient before and after operation; *C* and *D* show pre- and postoperative roentgenograms.

Result.—The patient has been very happy with the result. He has been working regularly packing boxes six to eight hours a day but has had occasional recurrent attacks of renal calculi and painful episodes with each hip. The hips show roentgenographic arthritic changes, but with steroid and roentgen therapy these have been fairly well controlled.

CASE 2.—A man, aged 31, had had back pain and increasing deformity for 12 years. The first four years he had several various types of medical treatment, to no avail. A brace was then prescribed, but deformity progressed. He had had his deformity for about six years and on admission was unable to look ahead at the horizon without bending his knees and hips. There was minimal head and neck motion and no demonstrable motion throughout the thoracic and lumbosacral spine. Routine laboratory tests revealed nothing unusual, although the sedimentation rate was slightly elevated. Osteotomy was performed at two levels, L1-L2 and L2-L3, Aug. 18, 1955.

Figure 2*A* and *B* show the patient before and after operation; *C* and *D* show the pre- and postoperative roentgenograms.

Result.—The patient had a recheck at 16 months and stated that his "back was perfect." He had been working regularly as a draftsman and had no complaints except intermittent pain in the left hip, which had a 30-degree contracture.

CASE 3.—A man, aged 30, had had a painful back for seven years and fixed flexion deformity for two years. Examination revealed limited head and neck motion but no thoracic or lumbosacral motion. Routine laboratory tests gave no unusual findings, and the sedimentation test was normal. Osteotomy was performed at L2-L3 on Sept. 14, 1955.

Figure 3*A* and *B* show the patient before and after operation; *C* and *D* show pre- and postoperative roentgenograms.

Result.—The patient is very happy and after correction was approved for adoption of a baby, which previously had been denied, owing to his spinal deformity. He is working regularly, eight hours a day, at a drill press. This patient lost correction between six and nine months after surgery, despite wearing his brace. He was advised to reenter the hospital after six months for hyperextension "stretching," but economic pressure prevented it. It was felt that with the deformity increasing the fusion was not solid and some correction could be obtained. He has not, however, had any further loss of correction.

CASE 4.—A man, aged 46, had had symptoms of back pain for 15 years and for 12 years had had gradually increasing deformity. He had received numerous types of medication and physical therapy, as well as wearing casts and braces, to no avail. He had had much difficulty in doing his work because of the severe deformity. There was no demonstrable motion of the thoracic or lumbosacral spine, and cervical spine motion was minimal. Routine laboratory tests revealed nothing unusual.

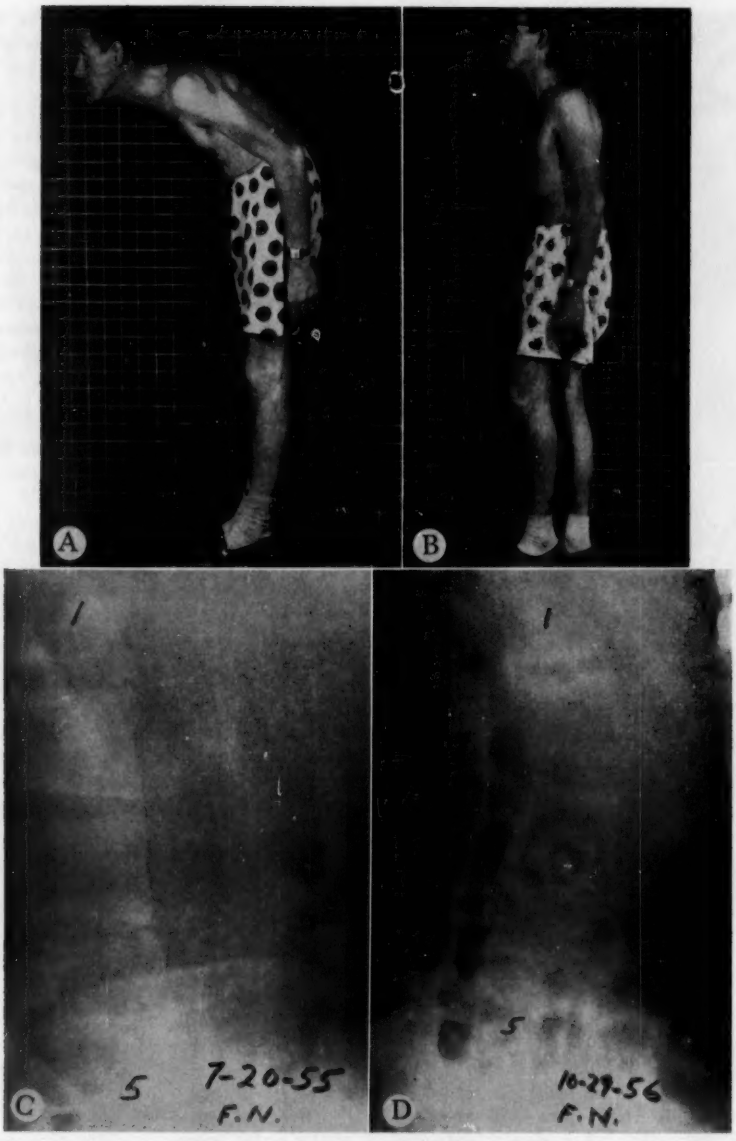

Fig. 2.—*A*, preoperative appearance; *B*, postoperative appearance, one and a half years. *C*, preoperative roentgenograms; *D*, postoperative roentgenograms, 15 months.

Osteotomy was performed at two levels, L1-L2 and L2-L3, on Jan. 12, 1956. Despite rather pronounced, long-standing anterior ossification, correction was obtained without difficulty.

Figure 4*A* and *B* show the patient before and after operation; *C* and *D* show pre- and postoperative roentgenograms.

Result.—The patient returned to work after seven months and works regularly in a personnel office. He is "very happy" with the result.

CASE 5.—A man, aged 37, had had symptoms of back pain for six years. The spine had stiffened in a forward flexed position, and the only demonstrable spinal motion was of the head and neck,

Fig. 3.—*A*, preoperative appearance; *B*, postoperative appearance, 15 months. *C*, preoperative roentgenogram; *D*, postoperative roentgenograms. The pictures show partial loss of correction.

in an amount of only 5 to 10 degrees. Various types of medication and physical therapy had kept him quite comfortable but did not halt the disease process or prevent the development of the flexion deformity. He had difficulty in "seeing ahead" and did so only with a good deal of effort.

He was admitted to the hospital on Nov. 28, 1956, by ambulance, having been in a traffic collision just before. He was dazed and did not recall all the details of the accident. His major complaint was pain in the back. Roentgenograms show his spine (Fig. 5*A*) in the early stages of the disease (Oct. 22, 1952) and (Fig. 5*B*) shortly after his injury. He was treated on a hyperextension frame for three months, then put in a body cast for six weeks and allowed to ambulate. He then wore a brace until a year's anniversary from the time of injury. At that time he said he was happy with the "new position" and his ability to "look ahead." He also said that at times he noted lack of bending forward to see the ground.

Figure 5*C* shows the patient, and *D* the roentgenograms, both nine months after injury.

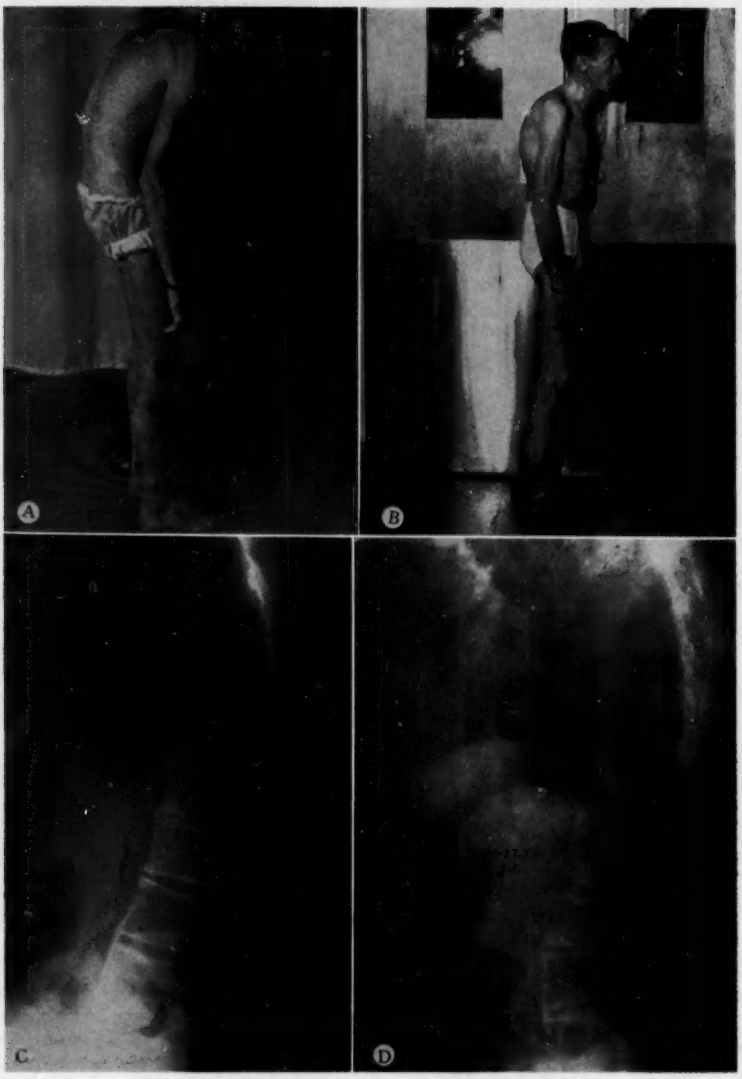

Fig. 4.—*A*, preoperative appearance; *B*, postoperative appearance, one year. *C*, preoperative roentgenograms; *D*, postoperative roentgenograms, one year.

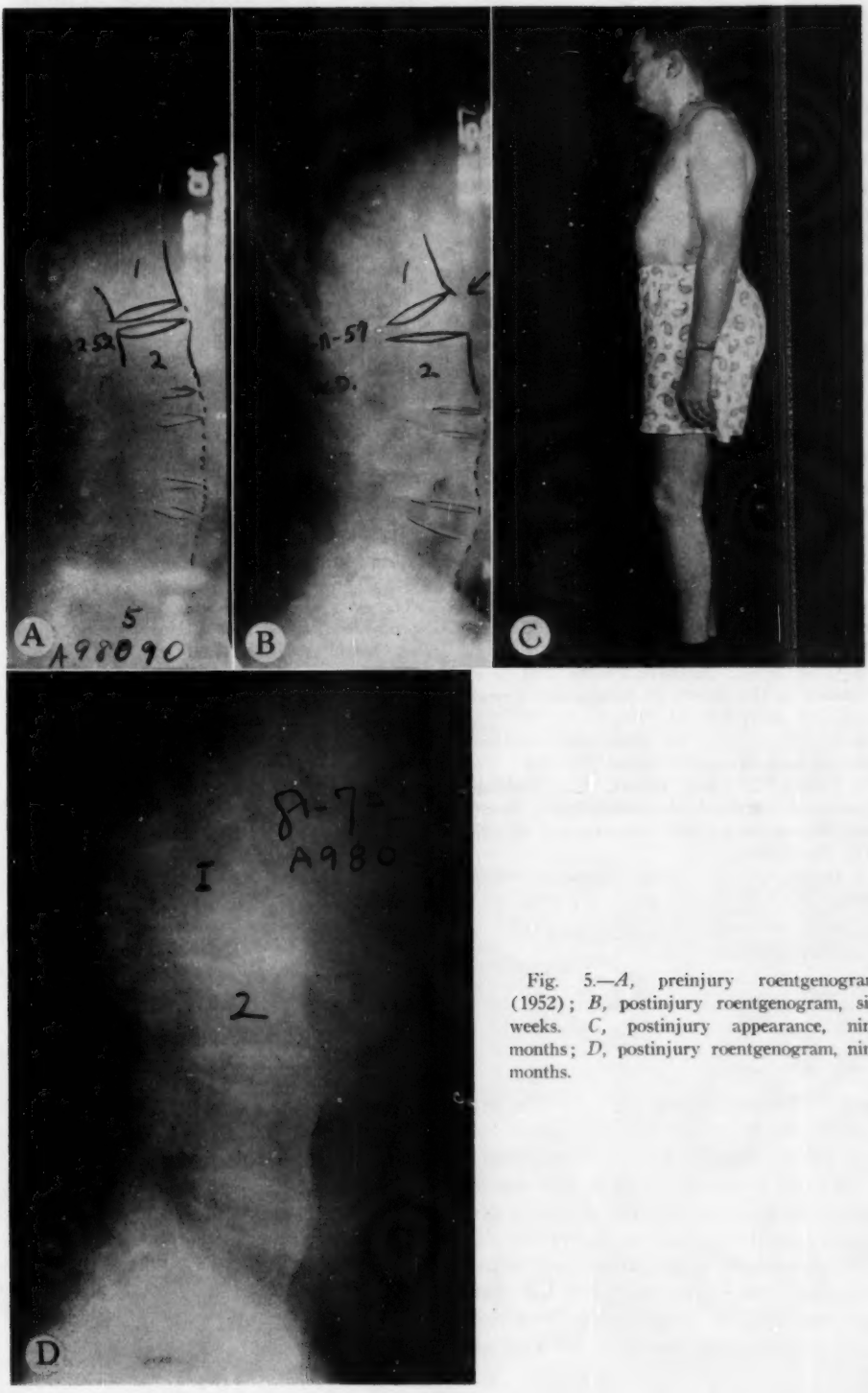

Fig. 5.—*A*, preinjury roentgenogram (1952); *B*, postinjury roentgenogram, six weeks. *C*, postinjury appearance, nine months; *D*, postinjury roentgenogram, nine months.

Summary

Five cases of osteotomy of the spine (four surgical and one traumatic), with observations and comments referable to the indications, procedure, complications, and results, are reported. The need for continued postoperative observation and adequate support for at least a year following surgery to prevent loss of correction is stressed. Careful attention to proper selection of patients and attention to details will give most satisfactory results.

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Presumed Radiation Carcinoma of the Tongue Base and Carcinoma of the Thyroid

Resection, with Tube Pedicle Repair; Report of a Case

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The diagnosis of radiation cancer is often difficult to verify, but certain neoplasms developing in tissues heavily irradiated 10 or more years previously might often be considered examples of this disease. Such is the status of the tabulated instances of radiation laryngopharyngeal cancer (Table). Goolden's monograph on this subject contains the statement that the original irradiated disease process must be benign for this diagnosis to be authenticated. Slaughter and Southwick [18] have recently written on mucosal radiation carcinomas and include two plausible instances in which second neoplasms followed the prior irradiation of other malignant tumors. The case to be described demonstrates the occurrence of a second neoplasm following external irradiation of the first malignant lesion, the original disease process persisting at the time of the final therapy. As can be seen in the Table, all of the other reported radiation cancers of the laryngopharynx have developed in areas where benign disease previously existed, toxic goiter and tuberculous adenitis heading the list of these entities. A communication from Frazell [7] states that through the years at Memorial Hospital a large number of patients with apparent radiation cancers of the oropharyngeal area have been seen, all having had previous external or interstitial radiation therapy for malignant tumors. Here the factors of time and location have for all intents and purposes elim-

Previously Reported Cases of Radiation Carcinoma of the Orolaryngopharynx

Case No.	Age	Sex	Original Condition Treated by X-Rays	Interval Between X-Rays and Lesion, Yr.	Anatomical Site	Pathology	Author
1	--	M	TB adenitis	13-16	Larynx	Squam. ca.	Lossen [14]
2	65	F	Goiter	20	Post. wall of hypopharynx	"Ca. simplex"	Kruchen [12]
3	52	F	Toxic goiter	5-9	Trachea and larynx	Squam. ca.	van den Wildenberg [24]
4	52	F	"Subhyoid tumor"	Not stated	Larynx	Squam. ca.	van den Wildenberg
5	59	F	Toxic goiter	20	Extrinsic larynx	Squam. ca.	Kindler [11]
6	43	M	TB adenitis	27	Aryepiglottic fold	Squam. ca.	den Hoed [5]
7	41	F	TB adenitis	23	Aryepiglottic fold and arytenoid cartilage	Squam. ca.	den Hoed
8	69	F	Toxic goiter	26	Pyriform sinus and aryepiglottic fold	Squam. ca.	Goolden [8]
9	50	F	Toxic goiter	28	Postcricoid area and aryepiglottic fold	Fibrosar.	Goolden
10	76	F	Toxic goiter	27	Postcricoid area	Squam. ca.	Goolden
11	49	F	TB adenitis	30	Pharynx and postcricoid	Squam. ca.	Goolden
12	51	F	TB adenitis	32	Postcricoid area and pyriform sinus	Squam. ca.	Holinger & Rabbett [10]
13	69	F	TB adenitis	30	Pharyngeal wall	Squam. ca.	Holinger & Rabbett
14	46	M	TB adenitis	27	Aryepiglottic fold	Fibrosar.	Holinger & Rabbett
15	53	F	Parotid carcinoma	9	Tongue	Squam. ca.	Slaughter & Southwick [18]
16	54	F	Ossifying fibroma of maxilla	21	Buccal mucosa	Squam. ca.	Slaughter & Southwick
17	48	F	Dermatitis of face	10-23	Hypopharynx	Squam. ca.	Slaughter & Southwick
18	62	M	TB adenitis	34	Pyriform sinus	Squam. ca.	Slaughter & Southwick
19	68	M	Metastatic squam. ca. cerv. nodes (primary nasopharynx likely)	13	Tongue	Squam. ca.	Slaughter & Southwick

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inated diagnoses of recurrent or metastatic lesions. Radiation cancer in other areas has been described by many authors, and a discussion of these papers will be limited to those covering the ocurrence of this phenomenon in deep structures. (Postirradiation skin carcinomas have been reported by physicians since the early days of the use of radium and x-ray.) Hatcher,[9] Cahan et al.,[2] and De Young[4] have reviewed the subject of radiation sarcomas of bone. Fibrosarcomas developing after x-ray therapy have been thoroughly outlined by Pettit et al.,[16] and Wilson and Brunschwig[21] have discussed sarcomas arising in areas repeatedly treated with the roentgen rays. A series of carcinomas of the body of the uterus in patients previously irradiated for benign uterine disease has been presented by Smith and Bowden.[19] The occurrence of carcinoma of the esophagus in a patient treated with x-rays for toxic goiter has been described by Ariel,[1] and one of apparent multicentric radiation mammary carcinoma has been presented by Lisa et al.[13] Duffy and Fitzgerald,[6] Simpson et al.,[17] and Clark[3] have described patients with carcinoma of the thyroid in whom radiation to benign enlargements of the thymus gland had previously been administered. Recently Ochsner[15] editorialized on this subject and outlined some of the reports on radiation thyroid carcinoma. The following case report has several unusual and interesting facets, in addition to what we believe is convincing evidence for a diagnosis of radiation carcinoma.

Report of Case

A 27-year-old white man was first admitted to Colorado General Hospital in April, 1941, with a history of having undergone a thyroidectomy in another hospital in 1936, followed by reexcision of the thyroid mass in 1940 at that same hospital. Details of these procedures were not recorded on the hospital chart. On admission to Colorado General Hospital, however, the patient was thought to have recurrence of the thyroid carcinoma, and resection of a large thyroid mass was performed, some of the lesion, however, being left behind at operation. An apparent metastatic mass lying lateral to the recurrent primary tumor was also removed. The patient received 4200 r in air by 250 kv. to the anterior neck after surgery. In November, 1942, the patient was readmitted because of the development of another mass in the right thyroid area, in addition to a mass more lateral in the right side of the neck. The large right thyroid mass was resected, but the lateral mass on the right was left in place. Some of the slides revealed only fibrotic postirradiation reaction in thyroid tissue, while others revealed minute foci of cancer. The patient received x-radiation following this procedure also, but the details have not been recorded. The patient was followed carefully until 1945, during which time no definite mass could be felt in the neck beneath the heavily irradiated skin.

This patient was lost to follow-up until October, 1955, when he came to the Bonfils Tumor Clinic of the University of Colorado Medical Center complaining of difficulty in swallowing of six months' duration. Examination at the time of this admission revealed far-advanced skin changes, with impending ulceration in the anterior cervical area (Fig. 1). On the left tongue base, with secondary involvement of the epiglottis, was a polypoid, partially ulcerated mass measuring 3 cm. in diameter, while in the neck was a 3 cm. right midjugular node. Extensive fibrosis prevented an accurate

Fig. 1.—Preoperative photograph showing extensive scarring from irradiation.

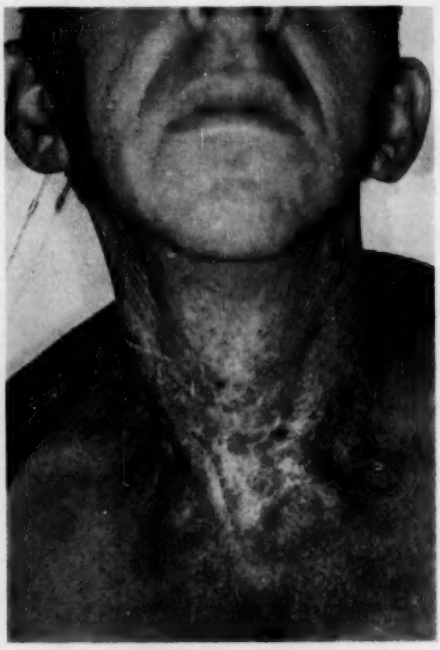


Fig. 2.—X-ray of patient's upper thorax and lower neck revealing calcific densities in right neck and upper mediastinum.

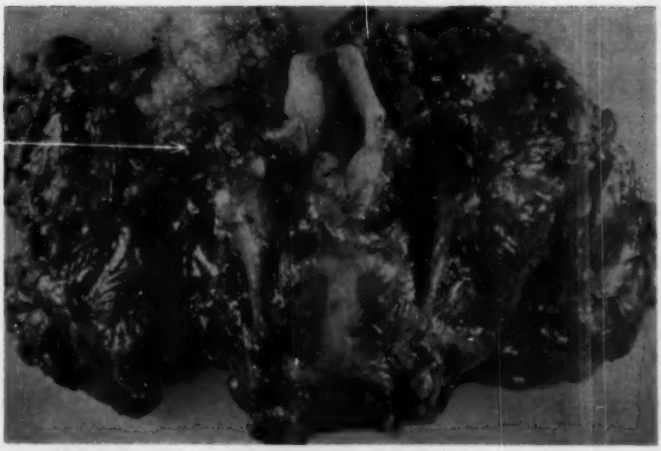


Fig. 3.—Operative specimen demonstrating ulcerated cancer involving left base of tongue and left side of extrinsic larynx.

examination of the neck. Biopsy specimens were obtained from the base of the tongue demonstrating squamous carcinoma, and aspiration biopsy of the right neck mass revealed metastatic carcinoma, possibly of squamous type. X-rays of the chest demonstrated several calcific densities located in the upper neck and mediastinum (Fig. 2). It was felt that this patient had squamous carcinoma of the tongue involving the epiglottis, in addition to metastasis in the neck, or possibly residual thyroid cancer. Because of the extent of the disease, bilateral neck dissection and resection of the tongue lesion with total laryngectomy was thought indicated. Owing to the absence of adequate skin and soft tissue to close a defect after the proposed procedure, a flap was delayed from the upper chest three weeks prior to the radical resection. On Nov. 4, 1955, a bilateral neck dissection, total laryngectomy, and resection of the posterior portion of the tongue were performed (by one of us, W. R. N.),

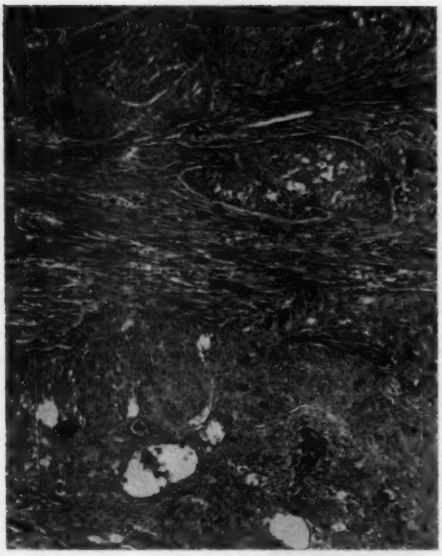


Fig. 4.—Photomicrograph of portion of tongue lesion showing invasive squamous carcinoma.

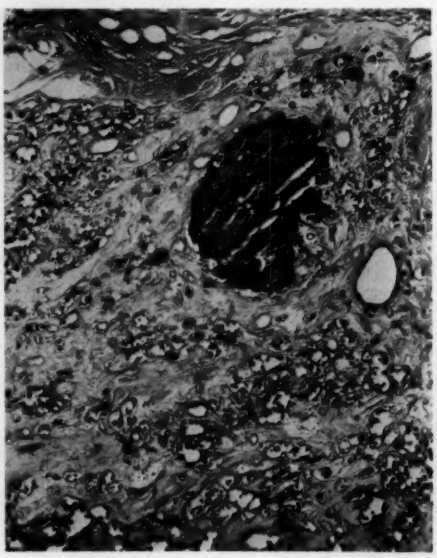
the heavily irradiated skin of the neck being resected with the specimen. The chest flap was swung into position and the tracheostoma brought out through this portion of tissue. Examination of the specimen revealed an ulcerated lesion of the left tongue base with secondary involvement of the epiglottis (Fig. 3). Microscopic studies demonstrated squamous carcinoma in the base of the tongue and epiglottis (Fig. 4), while the right cervical nodes were found to contain metastatic papillary thyroid cancer with calcification (Fig. 5). Extensive irradiation fibrosis was seen in the left cervical nodes, no tumor being found.

Approximately 7 to 10 days following surgery, necrosis in the chest flap developed, and subsequently a pharyngeal fistula developed. This complication was not unexpected in view of the extensive irradiation reaction in the deep neck structures and the all-too-brief delay of the chest flap, the latter procedure being carried out in the face of a rapidly growing squamous carcinoma of the tongue base. The patient's general condition was maintained by intensive tube-feeding therapy, in addition to intravenous administrations of fat and general supportive measures. The area of the fistula was meticulously irrigated and débrided to prevent involvement of the carotid artery by necrosis.

When it became evident that extensive repair would be necessary in this case, one of us (A. W. M. Jr.) began plans for tube-pedicle closure of the pharyngeal defect. The development of interpolated flaps covered by transferred skin and soft tissue was believed the method of choice in this regard, and so on Dec. 13, 1955, a large tube pedicle was constructed on the left anterior abdominal wall, extending obliquely from the left midaxillary line to the epigastrium (Fig. 6, Step *1*). Between Jan. 21 and April 24, 1956, the tube was "waltzed" to the upper pectoral area (Fig. 6, Steps *2* and *3*). On June 6 the opened and débrided distal tube was implanted over the lateral one-third of the fistula, where inverted skin flaps from the margin of the defect had been sutured in position to form a pharyngeal lining (Fig. 6, Step *4*). Next, on July 18, the tube was draped about the anterior cervical region as a necklace (Fig. 6, Step *5*), and, finally, the defect was closed on Sept. 13 by covering inverted skin flaps (which had been sutured together as a pharyngeal lining) with the tube pedicle itself (Fig. 6, Steps *6*, *7*, and *8*). The patient began without difficulty to swallow oral feedings approximately three weeks following the final stage. Massive facial edema, which had been present from the early postoperative phase, began to subside soon after the completion of the closure (Fig. 7).

This patient was last seen in the Bonfils Tumor Clinic of the University of Colorado Medical Center on Nov. 19, 1956, slightly over one year following the radical resection, and was found to be free of any evidence of recurrence. At that time he was swallowing without difficulty and was well on his way toward complete rehabilitation.

Fig. 5.—Photomicrograph of portion of one right cervical lymph node revealing papillary thyroid carcinoma surrounded by fibrotic reaction and areas of calcification.



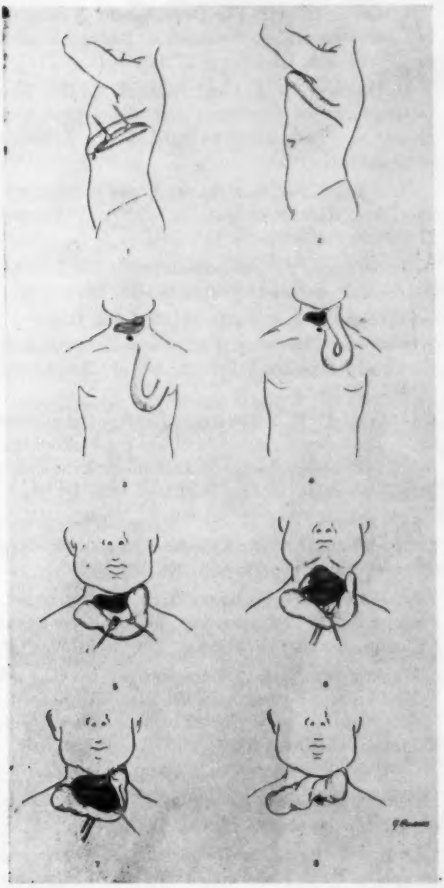


Fig. 6.—Steps in plastic repair of pharyngeal defect.

Comment

The case herein reported has numerous features which might be enlarged upon. A squamous carcinoma of the tongue base located in direct line with the x-ray therapy ports developed 13 years following irradiation for extensive papillary thyroid cancer, the latter disease apparently remaining stationary after treatment. Neoplasms due to the prior administration of x-rays and radium have been reported by many authors, and the criteria for such diagnoses have varied widely. The average time between x-ray therapy and the development of oro-laryngopharyngeal radiation cancers in the previously reported instances is 23 years (Table), an interval which falls in line with other published data on the subject. It is very likely that preexisting cancer of a type identical with the so-called radiation neoplasm would weaken the defense of this diagnosis if final proof is being sought. Evidence of extensive and lasting irradiation reaction in the presence of a new lesion lying in line with the x-ray ports would most assuredly add weight to this thesis. Actually, in nearly all of the cases in the Table advanced skin changes due to x-rays were demonstrated. In the patient described unusual calcification had developed in the original thyroid lesion, along with severe irradiation fibrosis, the latter giving rise to postoperative wound complications which necessitated extensive plastic repair of a pharyngeal fistula. The viability of the thyroid cancer at the time of the radical procedure is questionable, but the fact that recognizable papillary thyroid carcinoma was present would seem to indicate the extreme radioresistance of this particular neoplasm.

Fig. 7.—Photograph of patient six weeks after final stage of plastic repair.

Summary

A unique case is reported of apparent radiation carcinoma of the tongue base secondarily involving the extrinsic larynx in a patient treated for a carcinoma of the thyroid 13 years previously. The patient's second primary carcinoma and the thyroid carcinoma were treated by radical surgery, which resulted in a pharyngeal fistula, the latter complication being repaired by the tube-pedicle technique. A discussion is included of radiation carcinoma of the oro-laryngopharynx and other deep structures following x-ray treatment for unrelated conditions.

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Congenital Duodenal Obstruction

Report of Two Cases Occurring in Mother and Daughter, with Surgical Care

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There are many excellent reports in the literature dealing with the subject of congenital duodenal obstruction. This condition has been variously termed arteriomesenteric obstruction of the duodenum, chronic duodenal ileus, arteriomesenteric duodenal ileus, Wilkie's syndrome, and the superior mesenteric artery syndrome. Recent articles by Berley and Brown,[1] Canlas,[2] Kettenbach and Palumbo,[3] Telford,[4] and Findlay and Humphreys[5] report a small series of cases with reviews of previous publications. Most authors seem to be agreed that this type of obstruction takes place because of one of three underlying defects: (1) congenital anomalies of the intestinal tract with variations from normal bowel rotation; (2) accentuation of the normal angulation at the duodenojejunal junction (ligament of Treitz), or (3) pressure and compression of the duodenum at the duodenojejunal junction by the superior mesenteric artery and vein, due to a foreshortened and tightened mesentery.

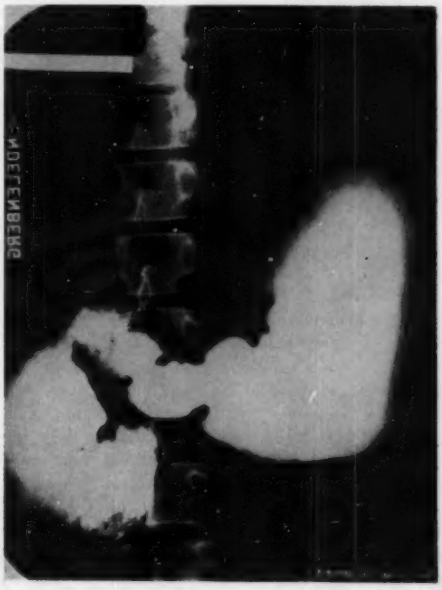
The following two cases are thought to be of special interest, as they constitute the first report of this condition in a mother and daughter. (The other children in the family, two brothers, were also examined, but gastrointestinal x-rays failed to reveal any abnormalities.)

Report of Cases

CASE 1.—The patient, a 14-year-old white girl, stated that as long as she could remember there had been occasional episodes of epigastric colicky pain, loss of appetite, nausea, and vomiting. Her mother added the information that the child had always been thin and undersized and customarily resisted all food. Examination revealed an undernourished, underdeveloped body but no other positive physical findings. A gastrointestinal x-ray series was reported as follows:

The stomach and duodenal cap revealed no evidence of any intrinsic or extrinsic abnormality. The barium passed readily from the stomach with normal peristalsis. The distal three-fourths of the descending arm of the duodenal loop and the beginning portion of its transverse arm showed a marked dilatation with ironing out of its mucosal fold, the visualized dilated duodenum ending rather abruptly (Fig. 1). A 30-minute film did not show any of the barium passing beyond the point of obtruction. Manual manipulation of the dilated duodenal portion under fluoroscopic visualization demonstrated a narrowing of that portion of duodenum immediately beyond the obstructed

Fig. 1 (Case 1).—Roentgenogram taken before operation, showing marked duodenal dilatation and partial obstruction of the terminal duodenum in the region of the duodenojejunal junction.



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From the Department of Surgery, the Central Medical Group of Brooklyn.

Fig. 2 (Case 1).—Roentgenogram taken 24 hours after ingestion of the barium meal, showing the stomach, duodenum, and small bowel emptied, with the opaque column evenly distributed throughout a normally situated ptotic large bowel.

area. This portion was smooth in outline, with its mucosa intact and no evidence of intrinsic disease.

One-hour films showed passage of some barium into the jejunum, as did the two- and three-hour roentgenograms. The six-hour film showed a slight amount of barium in the stomach, with the dilated duodenum still retaining the mixture, while the head of the barium column was in the ascending colon. The 24-hour film showed the stomach, duodenum, and small bowel emptied, with the barium meal evenly distributed throughout a normally situated and normal-appearing colon (Fig. 2).

The impression was that of a congenital band straddling and constricting the duodenum in the region where the superior mesenteric vessels cross the intestine.

The patient was admitted to the Jewish Hospital of Brooklyn on May 31, 1956, with a diagnosis of chronic duodenal obstruction secondary to the superior mesenteric artery syndrome. On June 4, with the patient under general inhalation anesthesia, a laparotomy was performed. Abdominal exploration revealed a normal stomach and large bowel. The descending and transverse portions of the duodenum were found to be hugely dilated, thin-walled, and saccular. There was a definite constriction and obstruction of the duodenum at the duodenojejunal junction (ligament of Treitz) caused by the superior mesenteric vessels. No other abnormality was noted in the area.

A retrocolic side-to-side anastomosis was performed between the dilated portion of duodenum and a loop of jejunum approximately 6 to 7 in. distal to the ligament of Treitz. In performing the duodenojejunostomy, interrupted black-silk sutures were used for the seromuscular layers and continuous chromic absorbable surgical (gut) sutures for the mucosal and submucosal layers.

The patient made a completely uneventful postoperative recovery and was discharged from the hospital on the 10th day after surgery. She has been in excellent health ever since, with no symptoms whatever referable to the gastrointestinal tract. There has been a marked increase in appetite, a gain of 11 lb. in weight, and an acceleration in all growth processes.

An x-ray study was done some three months postoperatively and revealed the following picture.

The stomach filled completely and revealed no pathological defect. The duodenal cap filled completely and appeared normal. Marked dilatation of the descending portion of the duodenum remained, but there was a good functioning small intestinal anastomosis and no evidence of obstruction in the area (Figs. 3 and 4). A five-hour film showed a slight amount of residual barium in the stomach and dilated duodenum, with the bulk of the column distributed through the ileum and colon.

Case 2.—The patient, a 32-year-old white woman, was the mother of the patient in Case 1. In discussing the child's condition, the mother revealed that she, too, had had trouble with her stomach and had been operated upon twice during a three-month period in 1954. The first operation had afforded temporary relief, but the abdominal pain, nausea, and vomiting had recurred and required a second operation. A report from the Maimonides Hospital of Brooklyn stated she had been operated upon two months previously at another institution. At the second operation, Dec. 13, 1954, marked obstruction of the third and fourth portions of the duodenum by the superior mesenteric artery was found. There was stenosis and obstruction of the previous duodenojejunostomy, which was attributed to "progressive scar-rings through the rent in the mesocolon and sharp kinking at the ligament of Treitz due to a short afferent loop to the duodenojejunostomy." A new duodenojejunostomy was performed, and the patient made an uneventful recovery, being discharged on the 15th postoperative day. She has remained in excellent health since this last surgical procedure, with no complaints referable to the gastrointestinal tract.

In October, 1956, approximately two years after surgery, a gastrointestinal x-ray series was performed and showed the following picture.

Figs. 3 and 4 (Case 1).—Roentgenograms taken three months after duodenojejunostomy, showing persistently dilated duodenum with a functioning anastomotic stoma.

Fig. 5 (Case 2).—Roentgenogram showing marked dilatation of terminal section of duodenum but with barium passing into jejunal loops through an apparent duodenojejunal stoma.

Fig. 6 (Case 2).—Roentgenogram showing incomplete rotation of large bowel. Dilated loop of duodenum with barium trickling into the anastomosed jejunum is seen.

The stomach revealed hypertrophy of the rugae but no evidence of pathological defect. The duodenal cap appeared normal. There was marked dilatation of the distal section of the duodenum near its junction with the jejunum, but there appeared to be no obstruction to the passage of barium into the jejunal loops. This was attribued to a functioning duodenojejunal anastomosis (Fig. 5). A barium enema study revealed nonrotation of the colon to the right side and the sigmoid in the midabdominal region and coursing toward the left. The transverse and ascending sections of the colon were in the left abdominal and pelvic areas (Fig. 6). All of the small bowel appeared to be on the right side of the vertebral column.

Comment

As Findlay and Humphreys have pointed out, there may be several causes for chronic duodenal obstruction. The mother and daughter reported herein, although both had marked duodenal obstruction, appeared to have different causes for their syndromes. The mother had malrotation of the intestinal tract with most of the large bowel on the left side of the abdomen and most of the small bowel on the right side. Her obstruction was caused by marked kinking of the duodenum at the ligament of Treitz, with many adhesive bands in the region. The daughter did not have nonrotation of the intestine and no evidence of adhesive bands at the duodenojejunal junction. Her obstruction was caused by the constriction of the superior mesenteric vessels in an otherwise normally constituted and positioned gastrointestinal tract.

It is worthy of note that duodenojejunostomy will cure this condition and should therefore be the operative procedure of choice. Attempts to mobilize the ligament of Treitz, to sever adhesive bands, or to lengthen the mesentery in the region would seem to be meddlesome and unnecessary. Furthermore, there is considerable danger of injuring the vitally important superior mesenteric vessels in any such maneuver. The failure of the first operation performed on the mother seems to have resulted from too small an anastomotic stoma and too short an afferent loop.

The two cases reported here, along with others in the literature, demonstrate a continued dilatation of the duodenum after duodenojejunostomy. Evidently, the loss of muscle tone over a prolonged period of time results in an inability of this segment of duodenum to regain its normal appearance and peristaltic function. Despite the persistence of the saccular deformity, obstruction is relieved and the duodenum will empty well, provided an ample stoma has been fashioned when performing the duodenojejunostomy.

Summary

Two cases of congenital duodenal obstruction, in mother and daughter, are reported. Perusal of the literature did not reveal a similar coincidence.

Each case appears to be of different origin, one being caused by nonrotation of the bowel, the other by a foreshortened arteriomesenteric attachment.

This type of duodenal obstruction can be cured by retrocolic duodenojejunal anastomosis with a wide stoma.

Severance of adhesive bands and attempts to mobilize the ligament of Treitz or to lengthen the mesentery in the region of the superior mesenteric vessels is not advocated.

Even after complete relief of obstruction, postoperative x-ray studies may reveal a markedly dilated portion of duodenum.

345 Schermerhorn St. (17).

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Gastric Volvulus

Special Reference to Hepatodiaphragmatic Interposition of Colon

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Gastric volvulus has been recognized for many years, and present-day knowledge of the essential features of this condition has been summarized by many authors.[1-6] The purpose of this presentation is to discuss certain unusual aspects of gastric volvulus which have come to our attention recently.

Gastric volvulus is an abnormal rotation of a portion of the stomach, either on its coronal or on its sagittal axis (Figs. 1, 2, and 3). Most cases of complete volvulus of the stomach may be associated with a pronounced degree of gastroptosis combined with a congenital lengthening of the gastrohepatic omentum and gastrocolic ligament. Normally, the gastrophrenic, diaphragmaticophrenic, and gastrolienal ligaments are sufficiently firm and strong in their normal positions that they anchor and support the upper portion of the fundus of the stomach, as well as the splenic flexure of the colon, in such a position as to prevent any extreme torsion. It would appear that any factor precipitating volvulus must include laxness of the normal aforementioned limiting ligaments. The stomach dome, in contact with the diaphragm and fixed by the phrenicogastric ligaments, is not moved appreciably unless it is subjected to unusual force or strain. The stomach thereby not only is anchored to the undersurface of the diaphragm but is more or less attached to neighboring organs. Any rotation or malposition of other neighboring organs may cause some torsion of the stomach. Gastric volvulus was produced experimentally in a cadaver by Dujon only after the gastrosplenic ligaments and the greater omentum were divided. In the usual circumstances the ligaments and vessels allow rotation through 90 degrees around its longitudinal axis. Any increase to the point of abnormal mobility of the stomach can be effected only by tremendous slackness or possibly rupture of these ligaments. Laxity or rupture of the stomach attachments as one of the most important etiological factors in gastric volvulus has also shown to be important in permitting the development of sufficient space under the diaphragm to admit the inverted stomach. In essence, congenital lengthening, stretching by force, or rupture of the gastrocolic omentum could be responsible for gastric volvulus. Finally, the duodenum and pylorus must be slack by virtue of an increase in the length of the mesentery to permit rotation on the axis of the stomach.

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Axis of Rotation

Rotation of the stomach upward around the longitudinal axis (coronal axis) is known as organoaxial volvulus.[7] In organoaxial volvulus the stomach twists from left to right and from below upward. When volvulus is complete, the anterior surface looks backward, while the posterior surface will present under the abdominal wall, sometimes veiled by the gastrocolic omentum. Rotation of the stomach from left to right, or vice versa, around the sagittal plane is known as mesenterioaxial volvulus[7] (Figs. 1, 2, and 3). Although Singleton[7] has followed von Haberer's classification,[8] it is germane to review the methods of rotation. Rotation can occur about three different axes, simultaneously.

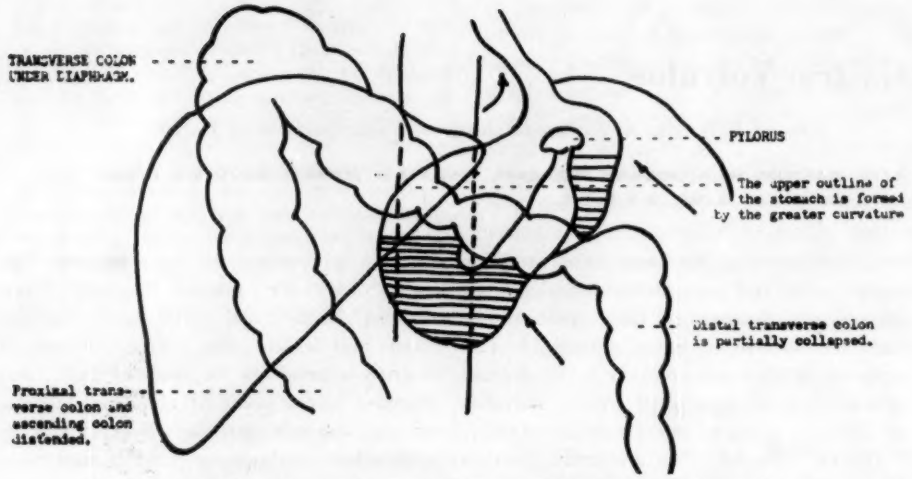

TRANSVERSE COLON UNDER DIAPHRAGM.
PYLORUS
The upper outline of the stomach is formed by the greater curvature
Distal transverse colon is partially collapsed.
Proximal transverse colon and ascending colon distended.

Fig. 1.—Organoaxial volvulus secondary to hepatodiaphragmatic interposition.

A. Mesenterioaxial Rotation.—Mesenterioaxial rotation occurs in the majority of cases. It would appear from an anatomical point of view that the rotation takes place from right to left around a vertical axis, at right angles to the cardiopyloric line. It may also occur from left to right about the vertical axis of the gastrohepatic omentum (radix mesenterii). The main reason for the majority of cases falling into this group is probably because the main movement is at the mobile pyloric end of the stomach. The pyloric end passes from right to left, then upward in front of the fundus of the stomach (Fig. 2). If one visualizes (diagram) a simultaneous opposite movement taking place at the fundus of the stomach, one can easily observe the anterior gastric wall folding upon itself or kinked. The posterior wall of the stomach is thereby pulled until it faces anteriorly under the abdominal wall enveloped by the greater omentum. With this type of displacement, there is also displacement of other neighboring organs.

B. Organoaxial Volvulus.—In organoaxial volvulus the axis of rotation is between the cardia and the pylorus. It is also common in this type of volvulus to have displacement of visceral organs, and this is especially true of the colon and the spleen. Following reduction of the volvulus, the organs are easily replaced.[7,8] According to Singleton, there are two types of organoaxial volvulus—one is supracolic and the other infracolic, depending upon the position of the colon. It is very likely that displace-

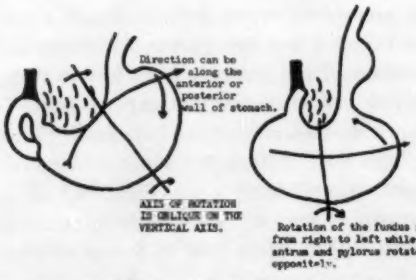

Direction can be along the anterior or posterior wall of stomach.
AXIS OF ROTATION IS OBLIQUE ON THE VERTICAL AXIS.
Rotation of the fundus is from right to left while the antrum and pylorus rotates oppositely.

Fig. 2.—Mesenterioaxial type of volvulus.

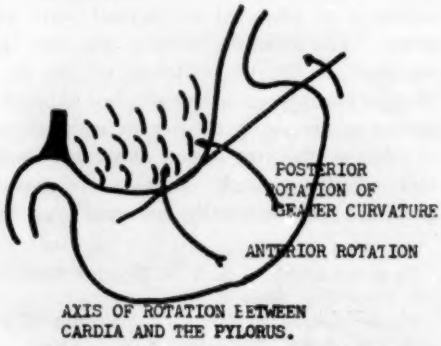


Fig. 3.—Organoaxial type of volvulus.

ment of other organs, mainly the transverse colon, may be responsible for the secondary displacement of the stomach. It is difficult to predict which is cause and which is effect. Hepatodiaphragmatic interposition of the colon refers to that condition in which a portion of the colon is located between the right leaf of the diaphragm and the dome of the liver.

The transverse colon will participate in this rotation process, either supracolic or infracolic. The relationship from an anatomical point of view is such that if the greater curvature rotates upward, the transverse colon will likewise be in a position to ascend (x-rays, Figs. 4-7). The more the greater curvature rotates, the more the transverse colon will be pulled upward in a position, until it finally is at about the level of the stomach, the stomach having rotated 180 degrees on its cardiopyloric axis. This type is supracolic and is the form that we wish to illustrate. Occasionally, the position of the transverse colon remains unchanged; that is, it is below the level of the rotated stomach. The position of the transverse colon, especially the flexures, in relation to the stomach accounts for many deformities of the stomach which occur after distention of the stomach. The colon is usually caught between the upturned stomach and the dome of the diaphragm and may show distention of the proximal one-half of the transverse colon. The colon in some instances cannot be replaced until the stomach is emptied. In a few instances it may be necessary to deflate or tap the stomach before the volvulus can be reduced. Recently, one of us (S. W. A.) operated on a patient whose colon was wedged between the diaphragm and the distended stomach. In this situation the proximal right half of the transverse colon was pulled upward and to the left between the liver and the diaphragm, causing angulation and subsequent obstruction not only to the stomach but also to the colon (Fig. 1). In other words, the colon is carried by the pyloric end of the stomach through its omental attachments to be pulled in front of the volvulus.

C. Anteroposterior Rotation.—Rotation about the anteroposterior axis is relatively unknown. This rotation takes place perpendicular to the paper.

D. Bidimensional Axes of Rotation.—It is important to realize that rotation around the two axes can take place simultaneously, that is, that an axis of rotation is somewhere intermediate between organoaxial and mesenterioaxial.

Etiological Factors

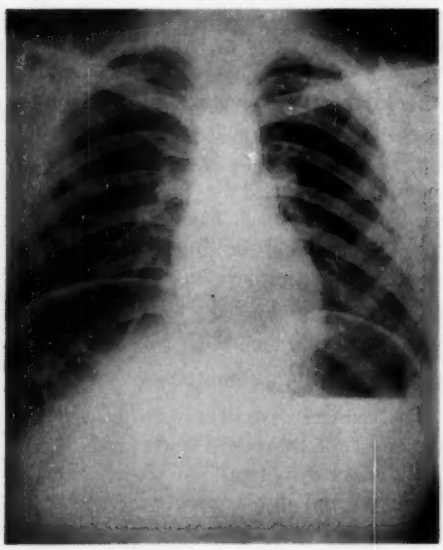
Gastric volvulus usually occurs in elderly persons. There is probably no difference in incidence in relation to sex. The literature seems to indicate many commonly associated lesions producing gastric volvulus. These include any intrinsic lesion of the stomach (usually the cardiac end), such as a benign or malignant neoplasm, peptic ulcer, or inflammatory process, e. g., gastritis, marginal ulcer, eventration of the diaphragm, or hourglass stomach; or any extrinsic lesion, such as might cause displacement by neighboring organs. This has been seen even in a gravid uterus. The presence of an abnormally long gastrocolic or gastrohepatic omentum has already been mentioned. The probability of vomiting associated with gaseous distention, congenital or acquired holes in the left diaphragm, or adhesions could also be implicated.[13,16,20] There is reason to believe that the most frequent cause of gastric volvulus described in the surgical literature is a diaphragmatic hernia.[12,14-16,20] In the perusal of the literature, abnormalities caused by failure of the descent of the stomach have also been mentioned. It would be interesting to note whether phrenicectomy has been associated with an increased incidence of gastric volvulus.

Symptomatology

The changes associated with gaseous distention of the transverse colon produce relatively minor symptoms. In severer cases of distention and displacement, the symptoms of gastrointestinal obstruction may be promi-

nent. Emptying of the stomach is interferred with, and the patient develops symptoms of gastric dilatation and insufficient emptying of the stomach. During the period of interposition the ascending part of the duodenum is displaced upward and to the right by the pull of the pedicle of the mesocolon or the gastrocolic ligament, and this displacement will produce abdominal pain. The relationship between intermittent interposition and the emptying of the stomach and duodenum is in accordance with partial and recurrent symptoms of upper intestinal obstruction. When the flexure of the colon returns to its normal anatomical position, the lax duodenum moves back to the left and the emptying of the stomach takes place. The severity of the volvulus accounts for either acute or chronic symptoms. The extent, direction, and severity of the rotation may account for a variety of symptoms. The average degree of twisting is approximately 180 degrees. Volvulus extending up to 180 degrees may be present without obstruction and may undergo spontaneous resolution or reduction. Any increase in the degree of rotation beyond 180 degrees may account for acute symptoms.

Fig. 4.—Haustral markings of the distended transverse colon beneath the right diaphragm.



It would appear from the majority of undisclosed cases that volvulus up to 180 degrees occurring without obstruction or strangulation very often undergoes spontaneous resolution. Rotation beyond 180 degrees presents a picture of an acute abdominal catastrophe; signs of acute obstruction occur. It is in these cases that death may occur if the volvulus is not reduced surgically. The initial effect of rotation is to close the pyloric end of the stomach by combined kinking and twisting (x-rays, Figs. 4, 5, 6, and 7). As the amount of rotation increases, the mobile pylorus moves toward the immobile cardiac end of the stomach, and this produces the folding of the lesser curvature into a deep V. As the distention of the stomach increases, there is a parallel increase in the amount of this midgastric constriction ring. When the torsion increases to a point where the pylorus approximates the cardia at one point, the two orifices may unite and form one pivot, around which further twisting of the viscus takes place. In other words, the openings

Fig. 5.—Total organoaxial volvulus, supracolic type—anterior rotation. The greater curvature is uppermost and adjacent to the diaphragm. The transverse colon and splenic flexure are related to the lesser curvature.

Fig. 6.—Right lateral recumbant and prone positions, illustrating the close proximity of the transverse colon to the stomach.

Fig. 7.—Marked hepatodiaphragmatic interposition with "aerocoly."

of the stomach are now converted to one fixed point. When this rotation exceeds 180 degrees, the lumina of the esophagus and duodenal orifices are occluded. The orifices are kinked, stretched, or displaced and then become occluded, resulting in further stomach distention. Experimental observations in the past have indicated that the pyloric obstruction probably occurs first. This adds further to the gastric distention. The distention progresses more rapidly once the cardiac orifice has been occluded. As rotation of the stomach continues, there is an initial effect of increasing gastric distention, and the effect of this gastric distention is pulling up of the pyloric end. As this volvulus proceeds, the pylorus approaches the cardia and the latter is stretched downward as it is fixed to the diaphragm. Obliteration of both orifices is an obstacle to emptying of the gastric contents and explains the extreme difficulty in passing a Levin tube at this point. With an increasing amount of distention and volvulus the ligaments give way under the strain and may rupture, further producing a vicious circle. This vicious circle parallels the direct relationship of occlusion and further distention, distention and further occlusion. When acute dilatation occurs in a stomach whose ligaments are either relaxed or ruptured, the normal rotation forward and upward continues. The rotation continues until the pylorus becomes angulated and occluded. Further rotation on a horizontal axis next occludes the cardia, and it is at this point that the Levin tube does not pass at all.

The pylorus was noted in our case to be situated above and in front; the cardia was hidden behind and a little to the left; both were kinked, compressed, and occluded on account of the torsion and enormous dilatation of the stomach. Acute torsion with compromise of the vascular supply to the stomach will present as an acute catastrophe, necessitating immediate surgical intervention. Recurring partial volvulus will usually present with persistent and recurring symptoms of partial high intestinal obstruction. In the acute type of torsion with occlusion of both orifices, bile will very rarely be present in the vomitus initially. The diagnosis of acute volvulus with extreme torsion

is rarely made before surgery. Many cases of recurring partial volvulus may be manifested by recurrent attacks of dyspeptic pain, with intervals of freedom for a variable period of time. The resemblance to peptic ulcer syndrome helps to confuse the picture. One common difference is probably the fact that the complaints in volvulus take place more quickly after the ingestion of food.

Radiographic Findings

The x-ray picture concerns itself with the differential diagnosis of "gas" between the liver and the diaphragm [21,25] (Figs. 4 and 6). These include (1) free air under the diaphragm, resulting from a perforated viscus or induced pneumoperitoneum, and (2) encapsulated subdiaphragmatic abscess. It is commoner to have large bowel interposed between the diaphragm and the liver than small bowel.[22] The haustral septal markings of gas-filled, distended colon traversing the radiolucent area beneath the right hemidiaphragm serve to differentiate large from small bowel. The gaseous distention of the transverse colon, known by French writers as *aerocoli,* can be recognized by the fact that the left half of the transverse colon can produce a filling defect in the greater curvature of the stomach to result in a bilocular type of stomach (Figs. 5 and 6). Increasing distention of the transverse colon implicates the colon and produces further biloculation of the stomach. This biloculated appearance may represent the first x-ray features of interposition of the colon. This interposition is characterized by such a displacement that the transverse colon travels upward in front of the stomach anteriorly and not uncommonly may reach a point such that the colon presents between the anterior surface of the liver and the right leaf of the diaphragm. In many cases there is an absence of the falciform ligament, which may be responsible for the colon being insinuated under the left leaf of the diaphragm. This condition has been referred to in the past as "falciform colon," or "anterior hepatodiaphragmatic interposition." [24]

Fig. 8.—Postoperative film following colectomy in which a cascade stomach is noted without obstruction.

The roentgenologic differentiation from simple cascade stomach may be very difficult. Some authors feel that volvulus of the stomach may be an exaggerated type of cascade pattern. One helpful hint may be that there is one fluid level in cascade stomach whereas there may be two fluid levels in gastric volvulus. Furthermore, the greater curvature of the stomach is uppermost in volvulus and is in a normal position in cascade stomach (Figs. 6, 7, and 8). The esophageal orifice is in the usual normal anatomical position in cascade stomach and is in a lower position in volvulus.

The cardia of the stomach may be the lowermost part of the stomach pattern, while the pars media will be situated adjacent to the diaphragm. In the x-rays one may see two barium-fluid levels evident in the fundus and in the antrum and two corresponding air-fluid levels. Borchard and Lenormant's triad in Toygar's article [19] is a helpful hint in the preoperative considerations. This consists of (1) vomiting without effect, (2) circumscribed epigastric pain, and (3) failure to pass a Levin tube.

Treatment

The treatment of gastric volvulus is surgical. In a case presenting the usual picture of acute dilatation of the stomach and when the Levin tube cannot be made to pass the cardiac orifice, laparotomy is indicated. Statistics seem to indicate that once volvulus takes place the chance of recurrence is very likely. Simple untwisting, detorsion, or replacement of the bowel into its normal abdominal position appears to be an inadequate method of treatment. Gastropexy or suturing of the stomach to the adbominal wall for cure of displacement is an antiquated operation for gastroptosis. Other operations to be condemned consist of shortening of the mesentery and shortening of the lesser omentum. The gastrohepatic omentum is shortened by pleating; the stomach and transverse colon are suspended anteriorly by pleating and suturing the gastrocolic and greater omentum to the anterior abdominal wall.[5]

These procedures are poorly chosen to correct this condition and should not be recommended. In order to form a correct therapeutic approach to this problem, it is necessary to appreciate the findings at surgery. Previously evacuation of gas and food content from the distended stomach and detorsion provided temporary good results in the majority of cases. Detorsion followed with gastroenterostomy gave better results. In recurrent cases in which hepatodiaphragmatic interposition is present the treatment of choice is primary resection of the transverse colon with end-to-end anastomosis. This has provided a satisfactory result in our case.

Report of a Case

An 18-year-old A/3C was first seen at Lackland Air Force Base Hospital complaining of intermittent burning epigastric pain. During a night march he noted the onset of sharp periumbilical pain accompanied by nausea, followed 10 minutes later by vomiting. He remained relatively asymptomatic for the next two months except for moderate "periumbilical cramps," which occurred immediately after the ingestion of food, and slight dysphagia to solid foods. In December, 1956, while at Chanute Air Force Base, he developed another episode of abdominal pain while eating breakfast. A scout film of the abdomen revealed marked gastric dilatation. This was followed 48 hours later by an upper gastrointestinal series, which confirmed the diagnosis of organoaxial volvulus (supracolic type) with interposition of the transverse colon. No intrinsic lesion of the stomach was observed. Ten days following the gastrointestinal series acute abdominal pain developed, and he was admitted to the 3345th U. S. A. F. Hospital. On admission the patient was acutely ill, dehydrated, and toxic. The abdomen displayed board-like rigidity and was diffusely tender, without localization. After an adequate period of hydration he was operated upon. A Levin tube could not be passed preoperatively.

At operation a picture of acute gastric volvulus was noted in which the greater curvature of the stomach was uppermost. The esophageal and pyloric orifices were completely occluded. The falciform ligament was absent. The redundant transverse colon (interposed between liver and diaphragm) was delivered into the wound; detorsion of the stomach was carried out, and a resection of transverse colon was performed.

Postoperatively, the patient did remarkably well and was returned to duty in two weeks. He has had no symptoms following surgery.

Comment

Although we must be frank to admit that we do not know the cause of this interesting phenomenon, it would appear that the main factor contributing to gastric volvulus secondary to hepatodiaphragmatic interposition is a long redundant transverse mesocolon, similar to that seen in sigmoid volvulus. The ligamentary apparatus of the stomach is lax to such a degree that secondary volvulus can occur as a result of the long redundant transverse mesocolon and colon. We feel that a distended colon with gas tended to lift the body of the stomach forward and upward and so produced a favorable position for the occurrence of volvulus.

It is apparent from our case that the stomach folded upon itself, not only on a coronal axis but on the longitudinal axis as well, in such a way that the antrum swings upward in front of the body of the stomach toward the left diaphragm near the cardia. At surgery the antrum and the fundus were

approximated, with the antrum lying slightly anterior to the fundus (Fig. 1). The condition is best examined from the diagrams in the posterior, anterior, and lateral views.

Hepatoptosis, or downward displacement of the liver, does not appear to be the essential feature of the condition, although it is possible that infrahepatic adhesions or relaxation of the hepatoduodenal ligament associated with an elevated diaphragm could be responsible for the set of circumstances outlined.

Although the initial cause of the volvulus was malposition and increase in length of the transverse colon, there were other responsible factors necessary for the gastric volvulus to take place, namely, a long duodenum with lax attachments. It is possible that abnormally strong peristalsis of the transverse colon dragged the greater curvature of the stomach upward toward the left diaphragmatic dome. It would seem that there must be vigorous peristalsis followed rapidly by an antiperistaltic wave to be responsible for this mechanism. Whether or not vomiting per se may produce mechanical torsion of the stomach is difficult to say. Toygar [19] suggested that a thick gastrocolic omentum together with strong colonic peristalsis produced volvulus in his case. The colon was seen to be above the inverted stomach, accompanying the greater curvature. In this situation the distention of the stomach obstructs the transverse colon secondarily, and therefore dilatation of the proximal colon and cecum occurred, as can be seen in the x-rays. The left portion of the transverse colon and the descending and sigmoid colon were partially collapsed, and the dilatation of the stomach and proximal colon varied inversely to the distention seen in the left colon.

In view of the increasing symptomatology of this patient, and in view of the progressive nature of the epigastric pain and vomiting of stomach contents and of the distention of the upper abdomen in the epigastric and hypochondrial areas, a laparotomy was performed. The gas-filled transverse colon was delivered, crossing in front of the stomach and noted to be between the liver and the right diaphragm. The absence of the falciform ligament was noted. This hepatodiaphragmatic interposition was temporary; the colon was delivered, and the position of the transverse colon was brought down. In order to prevent further recurrence of the exciting cause of the volvulus, it was felt that resection of the transverse colon should be effected in much the same way as one resects the sigmoid colon for volvulus of the sigmoid. This was accomplished by an isoperistaltic anastomosis between the limbs of ascending and descending colon. The stomach was deflated by means of a Levin tube after decompression was effected, and the patient's postoperative course was uneventful.

Summary

When the colon is insinuated between the diaphragm and the liver, and it is this which causes a gastric volvulus on its cardiopyloric axis, we refer to the volvulus as being due to a hepatodiaphragmatic interposition of colon. This causes the greater curvature of the stomach to be dragged upward by the transverse mesocolon in front of the lesser curvature of the stomach and thereby lie at an upper level.

The hepatic flexure and proximal transverse colon distorted the stomach by pressing up behind the liver to the right of the coronary ligament. We have suggested, therefore, that the distention of the transverse colon was the inciting mechanism in the production of gastric volvulus, and that, once the volvulus began, distention became progressive in nature and caused acute obstruction.

The conditions predisposing to gastric volvulus are reviewed.

The types, extent, direction, and severity of volvulus are discussed in relation to the symptomatology.

The methods of mechanism of gastric volvulus secondary to hepatodiaphragmatic interposition are discussed.

A case is presented in which partial organic obstruction was present in the proximal half of the transverse colon from interposition and which was amenable to surgical therapy, and in which in our follow-up studies revealed no further symptoms. A technique of colon resection as a method of treatment is outlined.

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Jaundice Due to Ascaris Obstruction of the Common Bile Duct in an Infant

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Jaundice in a 2-year-old infant in this country, secondary to an obstruction of the common bile duct by Ascaris lumbricoides, is so unusual that the following case is reported.

Report of a Case

A 2-year-old Negro boy had been in good health until 10 days prior to admission, when he developed severe watery diarrhea, associated with anorexia and weakness. Three days before admission he vomited an adult ascarid, and the very next day the mother observed that the child's urine was very dark and that his eyes had a yellow tint. The day before admission he vomited 20 more worms, but there was no history of his having passed any worms in the stools.

In his earlier history, the child had had no severe illnesses other than upper respiratory infections. At the age of 8 months he had been treated for an Ascaris infestation, after which he passed 50 worms; at this time also three of eight siblings had known Ascaris infestations.

On admission, his temperature was 103 F, his pulse rate 150 a minute, and his respiratory rate 60 per minute. The patient appeared acutely ill, lethargic, and dehydrated. The sclerae were markedly icteric. The abdomen was mildly distended and tympanitic. The liver was palpable 3 to 4 cm. below the right costal margin. Digital rectal examination revealed the stool to be light yellow in color. Examination of the urine showed a high concentration (4+) of bile, and the urobilinogen test was positive in a dilution of 1:40. The initial hematocrit was 42%. Examination of a stool specimen revealed the presence of an adult ascarid and numerous ova. It was negative for bile. The white blood cell count was 26,500 per cubic millimeter, with 50% polymorphonuclear leukocytes and 12% eosinophils. Hepatic function studies revealed a cephalin flocculation of 1+ and a thymol turbidity of 7.8 units, and the alkaline phosphatase was 8.7 units. The direct serum bilirubin concentration was 6.7 mg., and the indirect 2.7 mg., per 100 cc., the total being 9.4 mg. per 100 cc.

Dr. Ralph Platou, professor of pediatrics at Tulane University School of Medicine, suggested the diagnosis of Ascaris obstruction of the common bile duct and advised operation to relieve the obstruction. After several days of preparation with fluids and blood, a laparotomy was performed through a transverse supraumbilical incision under endotracheal anesthesia.

The gallbladder and common bile duct were found to be acutely distended and inflamed; and after opening the common duct an adult Ascaris occluding the lumen was removed. After a meticulous exploration of the extrabiliary tract for other worms, a T-tube was placed in the common duct. It seemed advisable to remove the gallbladder at this time because of the acute inflammation and distention. Multiple boluses of worms palpated throughout the small bowel were removed through two enterotomies—a total of 60 worms were removed.

On the fifth postoperative day a small ascarid came out of the T-tube to the collecting bottle. Other than this, the patient's postoperative course was uneventful. His jaundice cleared promptly, his temperature returning to normal in the immediate postoperative period. The T-tube was removed on the 10th day, and the patient was sent home on the 12th postoperative day.

Comment

Aviles [1] called attention to the wide and almost universal geographic distribution of Ascaris lumbricoides and stated that the pathogenicity of the parasite depended on three characteristics: (1) a poisonous material found in extracts of the worms; (2) infections disseminated by the migratory characteristics of the ascarid, and (3) mechanical obstruction of organs and viscera by a parasite or a group of parasites, which may be associated with the tendency of ascarids, particularly after treatment, to

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enter any small opening. Biliary-tract obstruction in a child or in an adult with a recent history of Ascaris infestation suggests the possible diagnosis of biliary ascariasis. Without this history the preoperative diagnosis of Ascaris obstruction of the bile ducts is seldom considered. Yang and Laube [19] reported 19 patients with biliary ascariasis who had symptoms compatible with acute cholecystitis; only 5 of the 19 patients were jaundiced. All of their patients were operated upon and found to have Ascaris in the common duct; yet the correct preoperative diagnosis was made in only four instances. Four of the nineteen patients whom they reported were children. Liu and Lee [13] reported a patient with symptoms of acute cholecystitis in whom a cholecystectomy was performed, and inside the gallbladder an adult Ascaris was found. Eberle's [7] patient, a boy 9 years of age, was explored for jaundice five months after having an appendectomy and was found to have three worms in the hepatic ducts and one in the gallbladder. On the 11th postoperative day two worms were removed from the biliary tract. Eberle [7] also referred to four adults who had gallstones and ascarids in the gallbladder. Ch'in [5] reported a 41-year-old Chinese housewife who died of hemorrhage secondary to the activity of an adult ascarid in the hepatic substance. The ascarid had produced a large hematoma, which subsequently ruptured into the peritoneal cavity. Shore and his associates [16] reported a 40-year-old white woman with a history of biliary-tract symptoms which recurred three years following a cholecystectomy. She was reexplored, and, because no disease was found at the time of operation, a T-tube was placed into the common duct. On the 12th postoperative day an ascarid presented itself at the cutaneous opening of the T-tube. Operative cholangiography, done at the time of exploration, had not disclosed a worm in the common duct. Ch'in,[6] in 1933, recorded a patient with acute hemorrhagic pancreatitis associated with impaction of an ascarid in the ampulla of Vater.

Smithies [17] and Zelditch [21] reported several patients, each with Giardia lamblia infestation of the biliary tract. Yi and Cho-Feng [20] found two patients reported in the literature and added one of their own, presenting with obstructive jaundice due to Clonorchis sinensis, a liver fluke.

As pointed out by Lawler [12] and Greaney [10] and their associates, the other causes of obstructive jaundice in this particular age group are malformations of the biliary tract, inflammatory disease of the biliary tract, and diseases of metabolic origin. In reviewing the literature, Potter [14] found references to a total of 432 children with gallbladder disease. In only 35 of these had a cholecystectomy been performed. Eliot [8] reported a patient with stenosis of a normal biliary tract through the action of contiguous cicatricial tissue. He postulated that when the area is distorted, angulation of the bile ducts may easily result in obstruction. He emphasized that, because of a constant low pressure of the bile current, surprisingly slight degrees of obstruction may result in jaundice. Many other instances of benign structures associated with jaundice have been reported.[3,4,9,11,15,18]

Cholecystectomy in the current instance was performed because of the acute inflammation of the gallbladder. In a similar circumstance, Butt [2] concluded that cholecystectomy should be done along with exploration of the common bile duct in view of the fact that ova might remain in the gallbladder and lead to a recurrence of the disease.

The gallbladder has been the focus of chronic typhoid infections; perhaps it might also provide, under the above circumstances, the focus of reinfestation of the bile ducts with ascarids.

Summary

The case of a 2-year-old infant with obstructive jaundice secondary to an ascarid in the common bile duct is discussed.

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Volvulus of the Midbowel and Its Resulting Intestinal Obstruction

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The occurrence of intestinal obstructions secondary to rotational anomalies is relatively frequent in infancy. Owing to the complex evolution of the midbowel, such anomalies are largely limited to it, and volvulus of this portion of the gastrointestinal tract is thus the commonest cause of obstructions secondary to rotational accidents.

Our knowledge of intestinal rotation had its origins in the pioneer work of Mall [7] (1898) and Frazer and Robbins [3] (1915). However, it was not until Dott [2] (1923) reported his clinical studies that a practical surgical application was made known. It remained for Ladd [5] to demonstrate that these obstructive phenomena lent themselves to easy surgical correction, provided that the problem was recognized and that the surgeon was familiar with the mechanism involved.

The embryology of intestinal rotation has been well reviewed by Gardner [4] and Aldrich et al.,[1] and reference is made to their excellent articles. However, it should be restated that when nonrotation occurs, the origin of the midbowel at the duodenojejunal junction and its termination at the midtransverse colon are adjacent to each other and that without adequate mesenteric fixation the entire midintestinal loop hangs from a slender mesenteric pedicle at the origin of the superior mesenteric artery. The tendency for a volvulus to occur around such a narrow base with inadequate fixation is obviously great (Fig. 1).

The commonest type of rotational anomaly occurs when the process of rotation, which takes place in a counterclockwise direction, is arrested prior to completion and the cecum fails to descend from the subhepatic area. Its position here may be either free or attached by peritoneal bands which overlie the third portion of duodenum. Should volvulus occur, which it usually does in a clockwise direction, not only is the blood supply to the midbowel compromised, as a result of torsion and compression of the superior mesenteric artery in its narrow pedicle, but, owing to traction on the peritoneal bands resulting from tension on the cecum by the twisting midbowel, pressure on the duodenum is increased and a high intestinal obstruction results. It was the failure to understand this latter component which gave rise to the disappointing results prior to its recognition by Ladd [5,6] and his introduction of a simple method of relief.

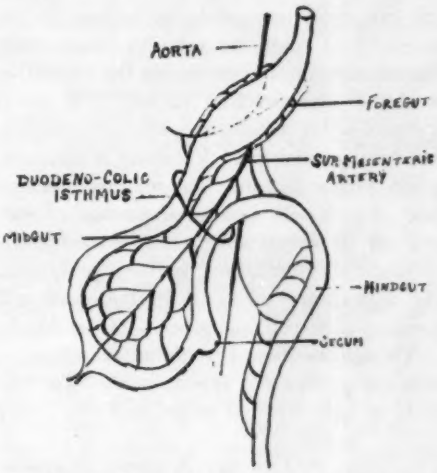

Fig. 1.—Position of midgut during second stage of intestinal rotation. Ring indicates narrow base between duodenojejunal junction and midtransverse colon about which volvulus may take place.

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Both components must be corrected: (1) The volvulus of the midbowel must be reduced, and (2) pressure on the duodenum must be relieved by dividing the peritoneal bands which fix the overlying undescended cecum, thus allowing this organ to migrate to the left side of the abdomen.

Symptoms of volvulus of the midbowel will depend on the degree of the twist and the extent of the vascular occlusion. In the majority of cases the volvulus occurs during intrauterine life or during the first three weeks of the neonatal period. The usual symptoms are those of partial or complete duodenal obstruction. Vomiting is constant, often projectile, and the vomitus contains bile. There will usually be passage of meconium or normal stool. Where the mesenteric vascular occlusion has been prolonged, the appearance of blood in the stool will indicate a necrotizing process (Case 3).

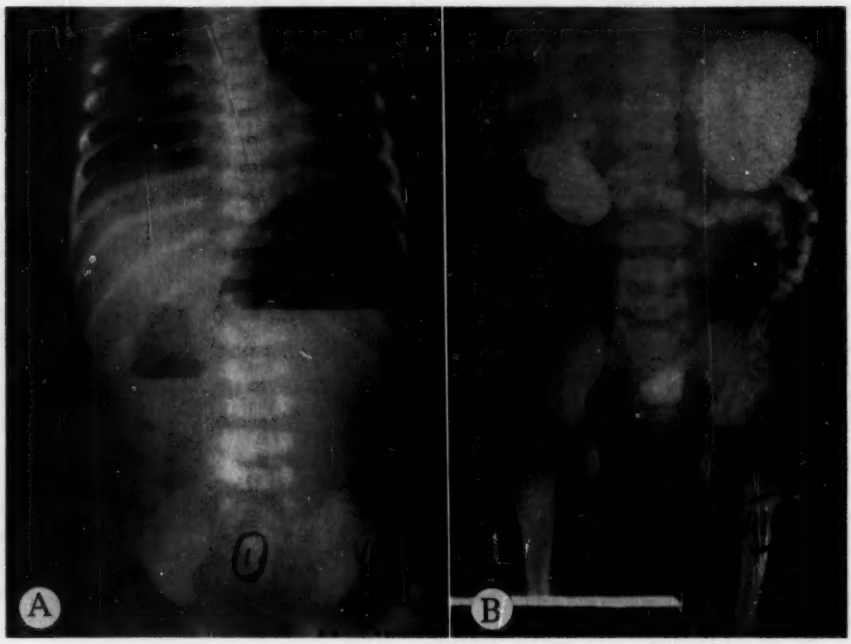
Though midbowel volvulus is not rare, this entity does not appear in the case records of this hospital prior to 1951. Since that time the condition has been suspected preoperatively in five cases and the diagnosis confirmed at operation. It has been our experience that a careful study of the plain preoperative x-ray film will enable one to suspect, and at operation to confirm, a volvulus of the midbowel in a high percentage of cases. It is our purpose, therefore, to correlate the symptomatology and operative findings with the preoperative roentgenograms in the following group of cases.

Report of Cases

CASE 1.—A 48-hour-old male infant was admitted with a history of repeated vomiting of bile-stained material, which began immediately after birth. There had been a passage of meconium on one occasion.

Examination revealed a normal newborn infant in relatively good condition. The weight was 2750 gm. Plain upright films of the abdomen revealed a markedly dilated stomach and duodenum and very little gas in the remainder of the gastrointestinal tract (Fig. 2*A*). Barium per os revealed obstruction of the lower portion of the duodenum, and barium enema showed the cecum to be in the

Fig. 2 (Case 1).—*A*, plain film showing markedly dilated stomach and duodenum with fluid levels. There is very little gas distal to the duodenum. *B*, barium meal showing dilated duodenum with complete block. Barium enema shows colon on left side of abdomen.



right upper quadrant and the entire colon to be present in the left abdomen (Fig. 2*B*). A diagnosis of midbowel volvulus was made.

At operation, following the evisceration of the entire small bowel from the peritoneal cavity, a twist of 360 degrees in a clockwise direction was seen in the mesenteric pedicle. This was reduced, and the cecum was then seen to be present in the right upper quadrant, overlying the duodenum. The lateral peritoneal attachments of the cecum were divided and the cecum displaced to the left side of the abdomen.

The postoperative course was uneventful, and the patient was discharged on the 17th postoperative day in good condition.

CASE 2.—A 9-day-old female infant was admitted to the hospital because of vomiting of two days' duration. The child had been perfectly well for one week following birth. She had taken feedings well, and stools had been normal. She had been vomiting bile-stained material repeatedly for 48 hours. The vomiting was projectile in character. Bowel movements had continued normal.

Examination revealed an essentially normal infant, considerably dehydrated and apathetic. The child had lost 450 gm. from a birth weight of 3000 gm. Roentgenologic examination with barium per os revealed almost complete obstruction of the third portion of the duodenum with dilatation of its proximal portion and the stomach (Fig. 3). Since the child had been entirely normal for one week, no atresia could be suspected, and a diagnosis of midbowel volvulus with duodenal obstruction was made.

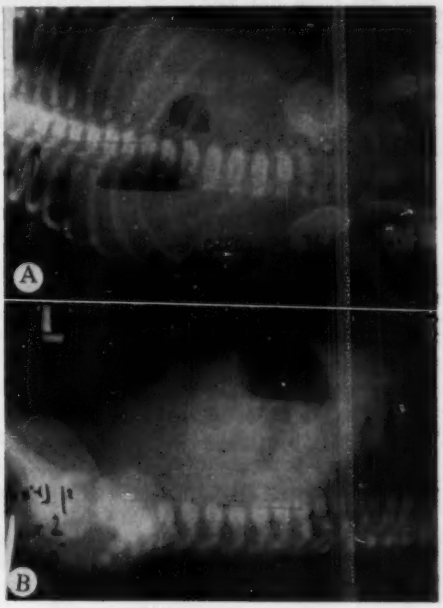
On exploration following evisceration of the small bowel, a clockwise twist of 360 degrees was seen in the mesentery. Following reduction in a counterclockwise direction the cecum was seen in the right upper quadrant in the same situation as in Case 1. The lateral peritoneal bands were cut and the cecum allowed to slide to the left side of the abdomen. The postoperative course was uneventful, and the child left the hospital on the ninth postoperative day.

CASE 3.—A 3-day-old female infant was admitted to the hospital because of vomiting of bile-stained material, which had begun immediately after birth. There had been several dark bloody bowel movements.

Examination revealed a dehydrated, jaundiced infant, in poor condition. The abdomen was markedly distended. The temperature was 39 C (102.2 F), and the white blood count was 42,000. The child had lost 300 gm. from an original birth weight of 3300 gm. Plain films of the abdomen showed some air in the stomach and the proximal portion of the duodenum, which was greatly dilated (Fig. 4*A* and *B*). There was a complete absence of air in the remaining portion of the gastrointestinal tract. A diagnosis of midbowel volvulus with duodenal obstruction was made. The

Fig. 3 (Case 2).—Barium meal showing dilated stomach and obstruction in third portion of duodenum. Some barium has passed beyond the duodenum.

Fig. 4 (Case 3).—*A*, plain film showing widely dilated duodenum with no air in distal bowel. B, lateral projection, showing more striking view of dilated duodenum. Patient was on left side in both views.



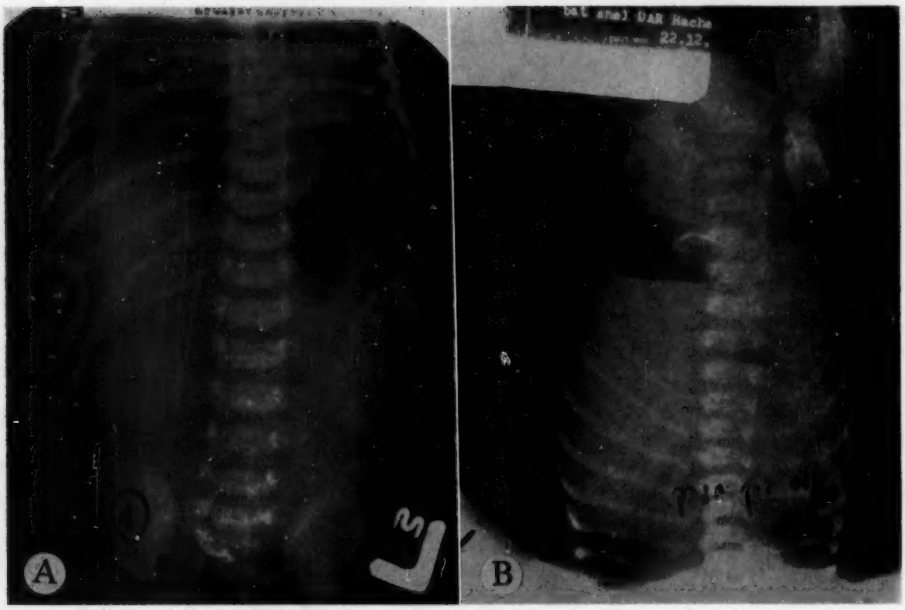


Fig. 5 (Case 4).—*A*, plain film revealing complete absence of air in gastrointestinal tract. *B*, film in head-down position following introduction of air through gastric tube, showing widely dilated duodenum with fluid level.

presence of bloody stools suggested the onset of gangrene.

At operation the entire small bowel from the ligament of Treitz to within 5 cm. of the ileocecal valve was found to be gangrenous. On evisceration of the small bowel, it was found to have undergone a complete double twist, that is, 720 degrees in a clockwise direction. On reduction, no pulsation was apparent in the mesenteric vessels. The gangrene was complete, and since no possibility of a living child could be contemplated with resection of the entire small bowel, the abdomen was closed. The child died five hours after operation.

Case 4.—A 4-day-old male child was admitted because of vomiting of bile-stained material, which began 24 hours after birth. During the first three days of life he had had a few scanty stools of normal color. There had been no stool in the 24 hours preceding admission. The child had lost 600 gm. of an original birth weight of 3000 gm.

Examination revealed a normally developed newborn infant, markedly dehydrated and in poor general condition. The abdomen was not distended. Plain roentgenograms revealed very little gas in the stomach and no gas in the entire remaining gastrointestinal tract (Fig. 5*A*). However, following the introduction of air into the stomach through a catheter, a plain film in the head-down position revealed a markedly dilated duodenum (Fig. 5*B*). A diagnosis of midintestine volvulus with duodenal obstruction was made.

At operation a 360-degree clockwise volvulus of the midbowel was found. The entire small bowel was cyanotic, but following the reduction of the volvulus the color rapidly returned to normal. Peritoneal bands extending from the lateral wall to the cecum in its subhepatic situation were divided; the duodenum was thus liberated and the cecum and colon displaced to the left side of the abdomen. The postoperative course was essentially uneventful, and the infant was discharged 15 days after operation.

Case 5.—A 5-day-old male infant was admitted with a history of vomiting of bile-stained material of three days' duration and abdominal distention. Bowel movements had been normal during the first three days of life, but there had been no bowel movements in the 48 hours prior to admission. The infant had lost 300 gm. from a birth weight of 2650 gm. Examination revealed a dehydrated, otherwise normal newborn infant. The abdomen was markedly distended. The temperature was 35.5 C (95.9 F). The white blood count was 25,400 per cubic millimeter. A plain x-ray film of the abdomen showed a marked distention of the small bowel. No air was present in the colon (Fig. 6). A diagnosis of mechanical small-bowel obstruction was made, but, because the clinical picture suggested a primarily duodenal obstruction, a mid-

Fig. 6 (Case 5).—Plain film showing diffusely dilated intestinal loops in left upper abdomen with absence of usual dilatation of duodenum.

bowel volvulus was considered a strong possibility, with gas trapped in the small bowel.

At operation a volvulus of the midbowel was found, with gangrene of 32 cm. of the terminal portion of the small intestine. The cecum was fixed in the subhepatic area and partially coiled about the mesentery. Following reduction of the volvulus the color of the bowel became normal except for the distal 32 cm., which was completely necrotic. The cecum was freed from its lateral attachments, the gangrenous portion of the small bowel resected, about 40 cm., and an end-to-side anastomosis accomplished between the ileum and the cecum. The postoperative course was complicated by a fecal fistula, which closed spontaneously, and the child was discharged four weeks after operation. When seen in the clinic, the child developed evidence of malnutrition, probably as a result of impaired intestinal absorption. He was readmitted to the pediatric department and died three and a half months after the operation, of bronchopneumonia, as revealed by autopsy.

Comment

Few intra-abdominal problems will present as confusing a picture to the surgeon on opening the abdomen as that of midbowel volvulus in infants where the possibility of such a condition was not previously considered. A careful study of the plain roentgenogram correlated with the clinical findings can as a rule establish such a diagnosis. Most commonly there is dilatation of the stomach and duodenum, with a fluid level present in each, and an absence of gas in the remainder of the gastrointestinal tract (Fig. 2*A*, Case 1). Occasionally this may be brought out more sharply by placing the child on his left side and taking films in the anteroposterior and lateral positions (Fig. 4*A* and *B*, Case 3). With such a roentgenologic picture and a history of repeated bile-stained vomiting, accompanied by normal passage of stool, the case for midbowel volvulus is a strong one. Confirmation of this picture by the use of barium per os is rarely, if ever, necessary and, owing to the persistent vomiting, may be dangerous because of the possibilities of aspiration. Figure 2*B*, Case 1, and Figure 3, Case 2, show the duodenal block demonstrated by barium meal. In either case the plain upright roentgenogram would have been sufficient. Barium enema may be of considerable value. Where the colon can be shown to lie in the left abdomen, malrotation can be suspected (Fig. 2*A*, Case 1).

Rarely, persistent vomiting will completely empty the stomach and duodenum, and on such occasions plain films will reveal an absence of gas in the entire gastrointestinal tract (Fig. 5*A*, Case 4). The introduction of a small amount of air into the stomach through a catheter, followed by placing the child in the head-down position, will enable the air to enter the duodenum, and plain films will demonstrate the dilated duodenum and its fluid level (Fig. 5*B*, Case 4).

Occasionally when volvulus has been present for some time, there will be marked abdominal distention and the roentgenogram will show diffuse dilatation of the small intestine (Fig. 6, Case 5). Under such circumstances only a diagnosis of intestinal obstruction can be made. However, where the clinical symptomatology was primarily that of duodenal obstruction, volvulus of the midbowel must be suspected.

The treatment of this condition is clearly operative, and should be undertaken as soon as the child can be brought into satisfactory condition. At operation the entire bowel must be eviscerated so that the mesentery can be clearly visualized, as this is the only way of determining the presence and direction of a torsion. Nearly always the twisting takes place in a clockwise direction. Detorsion is accomplished by lifting the entire bowel on its pedicle and twisting in a counterclockwise direction until the root of the mesentery is in normal position. Following this, the cecum must be mobilized by dividing the peritoneal bands which bind it to the posterior parietal peritoneum and the underlying duodenum. Once this has been accomplished, the duodenal obstruction will be relieved and the entire colon will be displaced to the left abdomen.

Results are uniformly good provided gangrene has not developed. Where necrosis has developed, owing either to the length of the process or to the degree of torsion, it is apt to be extensive, owing to thrombosis of the superior mesenteric artery. It may involve the entire bowel, precluding any hope of recovery (Case 3), or a long segment of bowel (Case 5), where extensive resections create difficulties of absorption, with inanition and death (Case 5).

Summary

1. Five cases of midbowel volvulus in infants are reported.

2. The necessity of considering this process in the preoperative diagnosis of intestinal obstruction is stressed.

3. The importance of the plain roentgenogram in the diagnosis is discussed, and the roentgenographic studies are correlated with the clinical findings.

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The Lumbothoracic Spine in Multiple Myeloma

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Despite the high incidence of backache in patients with multiple myeloma, little has been written about the specific changes in the vertebral column in this disease. It is our purpose to call attention to the roentgenographic findings in the spines of 58 patients with proved multiple myeloma seen at the Ohio State University Health Center in the past five years. Fifty per cent of this group entered the hospital with a complaint of back pain. Batts [1] and Ghormley [3] have also called attention to the high incidence of backache in multiple myeloma. While multiple punctate skeletal lesions have long been the roentgenographic hallmark of this disease, advances in the diagnosis of multiple myeloma have made it possible to recognize the disease in the absence of the classical findings. Indeed, in some cases roentgen examination of the spine may appear to be normal or may show only a mild degree of osteoporosis.

Because of the high incidence of backache in association with multiple myeloma, our comments will be directed mainly to the changes in the spine. At this point, it might be well to indicate the three major x-ray findings in the spine usually encountered at the time the diagnosis was first established. These were (1) a spine that was normal or showed only mild osteoporosis, (2) a spine that showed unquestionable osteoporosis with no other demonstrable lesion, and (3) osteoporosis with either compression fracture or lytic lesions or both. There are some points of general interest which must be considered prior to discussing the above changes in detail. The diagnosis of multiple myeloma is primarily a hematologic one. Other laboratory findings are used as adjuncts, such as anemia, Bence Jones proteinuria, hyperproteinemia, and, especially, hyperglobulinemia. The last abnormal finding exists chiefly as an elevation in the γ-globulin fraction of the serum protein. Clinically, pain and weakness are the commonest early symptoms. It is beyond the scope of this paper to include specific laboratory data or their interpretation leading to the diagnosis of multiple myeloma, since this is adequately discussed elsewhere.[1-5]

Bayrd and Heck,[2] in a comprehensive review of 83 proved cases, found that osteoporosis, compression fractures, and biconcave vertebral defects were present in the spine in 9% of their cases. Our series is based solely upon the roentgenographic manifestations at the time the diagnostic studies were being carried out in specific connection with this diagnosis. It is interesting, in view of what we are about to demonstrate, that Bayrd and Heck [2] wrote in 1947: "It should therefore be clear that multiple myeloma is not limited to those cases in which gross bony changes develop, and the diagnosis must in no instance be prejudiced by the absence of these changes." In 1942, Ghormley [3] wrote: "We have been embarrassed at our inability to discover a definite skeletal focus on examination of a patient who is dying and has all other clinical signs and evidence of multiple myeloma."

When we study the general x-ray picture, we note that osteoporosis, either with or without osteolytic lesions, is by far the most consistent finding (Fig. 1). Turning our attention to the specific roentgen changes in the spine in multpile myeloma, we find seven distinct categories in this series (Table).

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Fig. 1.—Mild osteoporosis only.

X-Ray Findings in Spines of Fifty-Eight Patients with Multiple Myeloma at Time of Diagnosis

	Cases	Per Cent
Normal or mild osteoporosis	16	28
Osteoporosis alone	18	31
Osteoporosis and one or more compression fractures	16	28
Lytic lesions of the spine	6	10
Osteoporosis with severe biconcave defects of vertebral bodies	2	3
Vertebra plana or complete destruction	2	3
Intervertebral disk involvement (some categories overlapped)	1	1.7

From this Table it can be seen that 59% of the cases had a normal spine or osteoporosis alone at the time the diagnosis was established. This finding could be alarming in view of the large numbers of patients with backache whose diagnostic work-up is confined to the examination of the back,

Fig. 2.—Cervical spine showing widespread lytic lesions in absence of aerated structures.

Fig. 3.—*A*, lumbothoracic spine of a patient with multiple myeloma. *B*, spine of the same patient, x-rayed post mortem, one day after *A*. The spine was freed from soft tissue at autopsy.

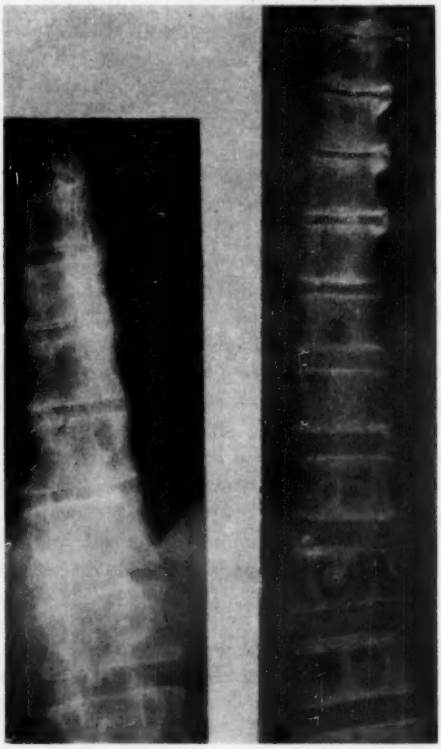

Fig. 4.—Compression fractures of T12 and L2 with associated biconcave defects of vertebral bodies.

Fig. 5.—Osteoporosis and biconcave defects alone.

including spine roentgenograms, on an outpatient basis.

Lytic lesions of the spine are frequently obscured by an aerated lung or gas in the bowel, so that they are first elicited in the pelvis, proximal femur, lateral portion of the scapula, or skull. For this reason, lytic lesions may be well demonstrated in the cervical spine, rather than in the thoracic or lumbar spine (Fig. 2). The aerated lungs, gas in the intestine, and soft tissue surrounding the lumbothoracic spine in the presence of osteoporosis undoubtedly mask the lytic lesions considerably (Fig. 3*A* and *B*).

Compression fractures, either solitary or multiple, associated with osteoporosis, may represent an early manifestation of multiple myeloma (Fig. 4). Depending upon the degree of associated osteomalacia, biconcave vertebral defects may be presented as the dominant picture (Fig. 5). Or, compression may be carried to the extreme degree to produce vertebra plana, as in Figure 6, or even complete loss of a vertebral body.

While ordinarily we do not consider neoplastic diseases of the spine involving the intervertebral disk space, one of our cases did present this situation (Fig. 7A). The reduction in disk space and the destruction of the contiguous vertebral end-plates are

Fig. 6.—Vertebra plana from multiple myeloma.

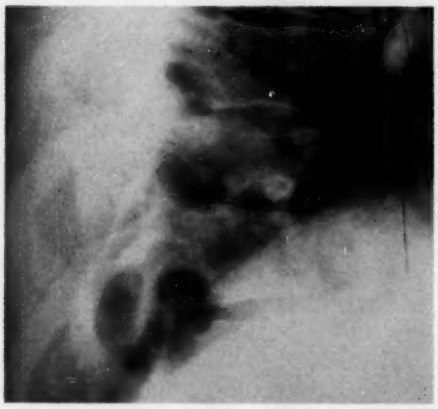

Fig. 7A.—Mild reduction of the intervertebral disk space.

apparent, followed by complete bony block (Fig. 7B).

The amount of lytic lesions does not necessarily reflect the severity of the disease. Progression from an apparently normal spine and pelvis to one with widespread lytic lesions may develop within a few months. Similarly, we have seen several cases of death from multiple myeloma with no roentgenographic changes. Fifty-three per cent of the cases showed punched-out lesions of the skull at the time of diagnosis, whereas in still others lesions developed as the disease progressed.

Correlation of the cases with an initial complaint of backache and the x-ray findings in the spine showed that of the 16 patients whose spines were normal or showed mild osteoporosis, 6, or 31%, had a presenting complaint of backache. Of the 18 patients showing moderate to severe osteoporosis of the spine, 7, or 39%, complained of backache initially. As expected, a high proportion, all but 2, of the 18 patients with compression fractures gave backache as one of the early complaints (Fig. 8).

Summary

Constantly improving diagnostic techniques leading to earlier diagnoses than in

Fig. 7B.—Spine of the same patient as in Figure 7A, 17 months later, showing complete bony block.

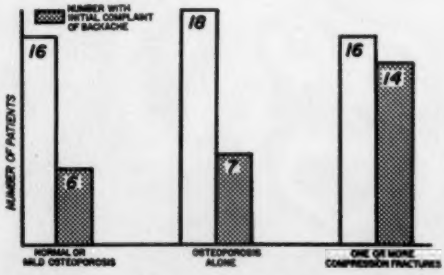

Fig. 8.—Correlation between back complaint and initial spine x-rays.

the past have necessitated revision in one's thinking in regard to a fixed roentgenographic pattern in multiple myeloma.

While we have illustrated various types of lesions found in patients with multiple myeloma, attention is called to the fact that early in the disease the classical x-ray findings of multiple punched-out lesions are encountered only rarely in the spine.

In this series of 58 cases diagnosed between 1951 and 1956, the spines were either normal or osteoporotic alone in 59%.

The diagnosis of multiple myeloma should be considered in the case of any patient who has backache and osteoporosis.

The Hematology Division, Ohio State University College of Medicine, not only gave free access to all their cases but also provided valuable advice and encouragement in this study.

University Hospital (10) (Dr. Smith).

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Priapism Secondary to Metastatic Malignancy

Report of a Case

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Malignant priapism is a term originally coined by Peacock [7] in 1938 to describe a condition of painful induration and erection of the penis due to infiltration by secondary neoplasm. In the case which he presented the patient developed penile metastases one and one-half years following treatment of a bladder carcinoma by transurethral fulguration. The penile lesion was found to be carcinoma metastatic from the bladder; and, when the patient died shortly thereafter, diffuse metastases were found.

This subject was reviewed in 1956 by Paquin and Roland,[6] who summarized reports of 55 such cases from the literature and added 9 cases, making a total of 64 case records. Study of these patients indicated that the origin of the neoplasm which metastasized to the penis was the bladder in one-third of the cases. Neoplasms of the rectum and prostate accounted for 39% of the cases reported. The methods of spread were well outlined in this discussion, it being concluded that direct extension and retrograde venous or lymphatic spread were probably the commonest routes.

It should be noted that priapism is very rarely due to neoplasm. Of 170 cases of priapism reviewed by Hinman [2] in 1914, only 2 were due to neoplasm.

A feature of considerable interest is that in a number of these cases malignant priapism occurred sometime after a transurethral or open operation for carcinoma of the bladder. Along this vein, in 1950 Baker [1] presented four cases in which metastases to the penis developed from primary carcinoma of the bladder. More recently, several authors [5,6] have presented cases illustrating the transplantability of the bladder tumors and have emphasized this hazard, particularly during transurethral resection or open fulguration of bladder tumors. McDonald and Thorson [5] demonstrated that bladder tumors in dogs are readily transplanted to isolated bladder pouches.

In an attempt to clarify some of these matters, the following case report is presented.

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Report of Case

A 60-year-old man entered the Seattle Veterans' Administration Hospital May 29, 1956, complaining of painful swelling of the penis of several months' duration. In 1955, at the Vancouver Veterans' Administration Hospital, the patient was found to have two large papillary neoplasms of the anterior bladder wall. On Sept. 15, 1955, these lesions were excised and fulgurated suprapubically. The tumor proved to be Grade 3 papillary carcinoma of the bladder.

Because of recurrence around the left ureteral orifice, suprapubic excision and fulguration of the tumor were repeated on Dec. 8. At the same time suprapubic prostatectomy was carried out. The pathology reported revealed a Grade 3 papillary carcinoma of the bladder and benign prostatic hyperplasia. On May 3, 1956, the patient was found to have a hard mass involving the shaft of the penis. This was present and had developed gradually over the previous month. Aspiration biopsy of the penis revealed metastatic carcinoma. The patient was transferred at this time to the Seattle Veterans' Administration Hospital.

At the latter hospital the patient complained of persistent painful penile erection, moderate urinary frequency, dysuria, and some hematuria. He had no difficulty in emptying his bladder, however, and was observed to be in fairly good general health.

An intravenous pyelogram revealed a nonfunctioning left kidney. A large filling defect was observed involving the left side of the bladder. A retrograde urethrogram revealed no significant

Fig. 1.—A retrograde cystourethrogram. The postprostatectomy defect and irregularity of posterior bladder wall due to neoplasm are noted. The urethra is not unusual except for slight narrowing of the bulbous portion.

abnormality other than a slight narrowing of the bulb of the urethra (Fig. 1). Cystoscopy revealed the left lateral bladder wall to be occupied by a large tumor mass. The entire urethral mucosa was intact despite the obvious neoplastic induration of both corpora cavernosa throughout the entire course of the penis.

In view of the apparent localized nature of the disease, and despite the presence of metastatic disease in the penis, it was elected to attempt extirpation of the neoplasm. On June 21, 1956, a total cystectomy with complete removal of the penis was carried out, without event. The ureters were transplanted into the sigmoid colon. The neoplasm was found to have extended through the entire bladder wall with obvious gross invasion of numerous lymph nodes, including one anterior to the distal aorta. The pathology report follows.

Gross Examination.—The left lateral wall of the bladder is involved with a tumor mass, measuring 5.0×4.0×3.0 cm. The distal portion of the left ureter is grossly dilated, the site of obstruction being at the ureterovesical junction. Transverse sections through the entire penis demonstrate diffuse involvement of the corpora cavernosa and the corpus spongiosum with firm white tumor (Fig. 2).

Microscopic Study.—Sections from the bladder reveal transitional-cell carcinoma, Grade 3, invading the entire wall (Fig. 3). There is tumor invasion of the veins and lymphatics of the bladder wall. The adjacent prostatic fossae are not involved by the tumor. Microscopic sections from the penis show tumor at the proximal line of resection. The tumor invades the corpora cavernosa and is present in the lymphatics and blood vessels (Fig. 4). It should be emphasized that

Fig. 2.—Cross section of the penis. Extensive neoplastic involvement is apparent.

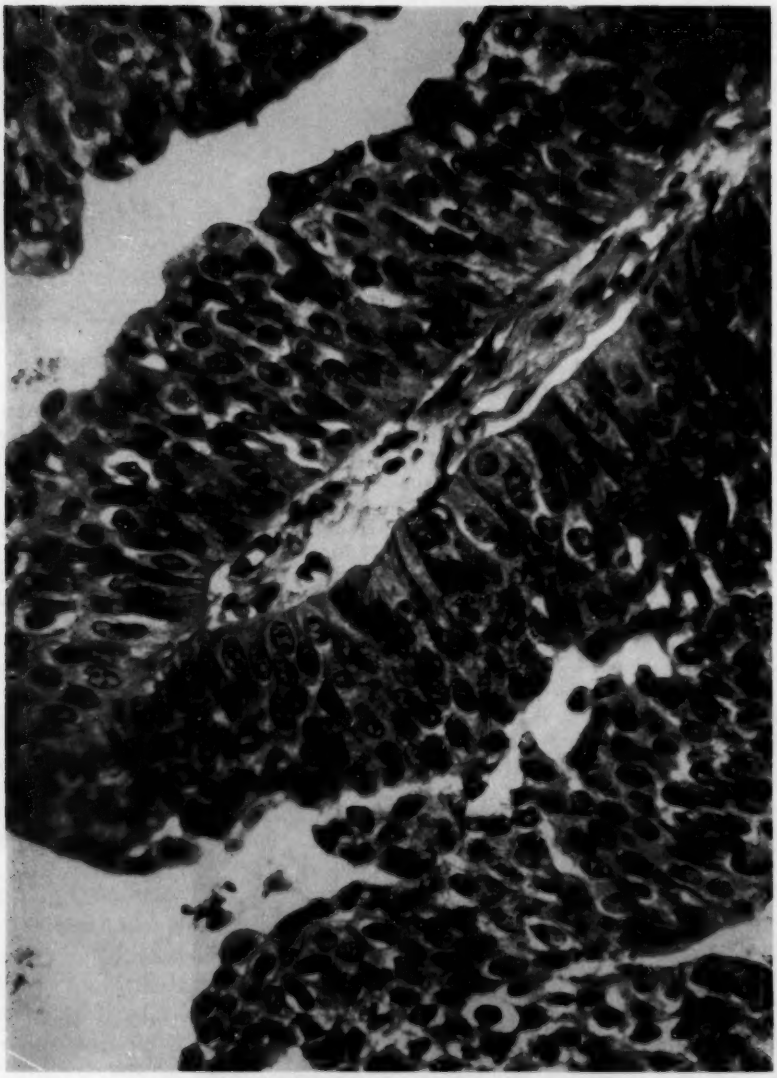

Fig. 3.—Photomicrograph of the primary lesion in the bladder. This illustrates the papillary nature of the lesion. Approximate magnification, × 400.

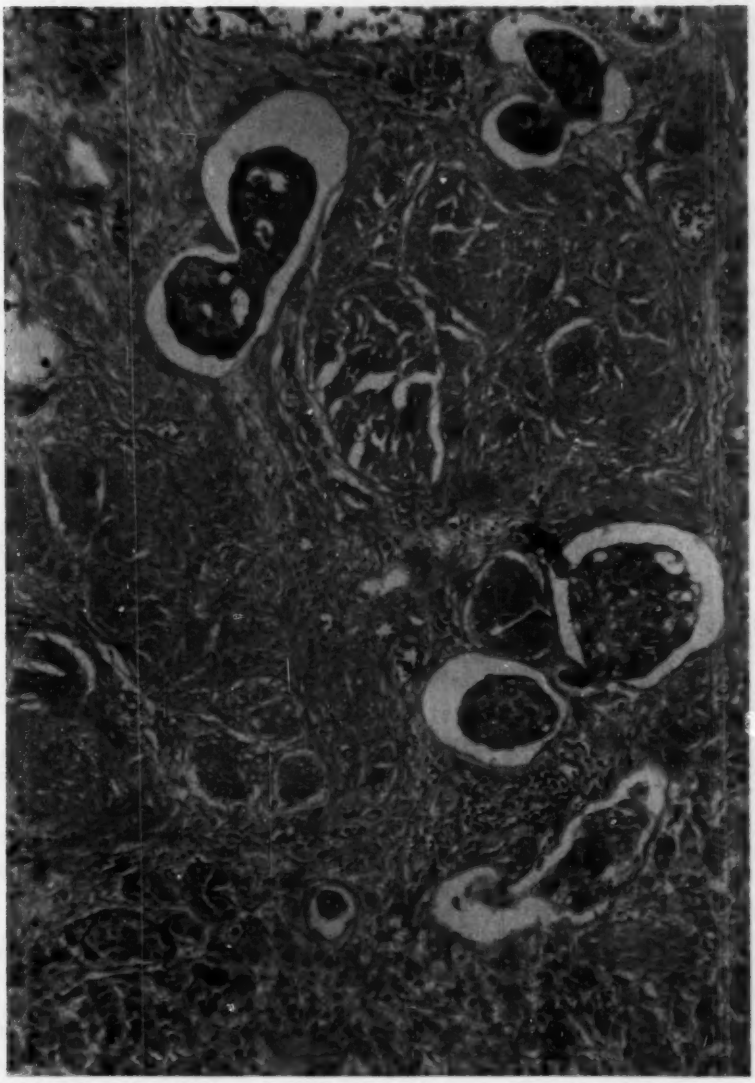

Fig. 4.—Photomicrograph of the metastatic lesion in the penis, illustrating the widespread vascular and lymphatic involvement. Approximate magnification, × 200.

there was extensive invasion of the submucosa of the urethra, but the urethral mucosa was uninvolved.

Postoperatively the patient developed severe pains in both legs and in the pelvic region. On July 11, 1956, the patient was found by x-ray to have extensive neoplastic destruction of the pelvic bones. He was treated with palliative x-ray therapy, with slight relief. He deteriorated rapidly and died at home in September, 1956, three months following surgery.

Comment

Although autopsy was not performed, there was ample evidence at the time of cystectomy that extensive disease existed in the pelvis with extension into the plevic lymphatics. It would appear logical to assume that the metastatic spread to the shaft of the penis developed as a result of the retrograde lymphatic and venous extension. The absence of neoplastic involvement of the urethral mucosa and prostatic fossae rules out the possibility that transplantation of tumor into the penis occurred as a result of urethral instrumentation, prostatectomy, or suprapubic fulguration of the primary tumor.

The diffuse nature of the neoplastic spread within the penis itself is also against spread by transplantation. Hinman [3] presented three cases in which tumor recurred at the bladder neck following simultaneous bladder-neck resection and transurethral removal of bladder papillomata. Kiefer [4] presented five similar cases, in which the recurrence involved either the urethral or the vesical mucosa. In neither of the above series were the deeper penile or prostatic tissues involved by tumor.

One might conclude that the presence of malignant priapism is almost certain evidence of extensive disease involving the pelvic viscera, vessels, and lymphatics and that it is not a sequel of transurethral or transvesical transplantation. The importance of establishing the mode of spread is that therapeutically the presence of malignant priapism probably indicates that surgery, regardless of how radical, will be of no value in eradicating the disease.

Summary

Malignant priapism is a rare manifestation of extensive bladder carcinoma, which probably occurs as a result of retrograde venous and lymphatic extension. Emasculation together with cystectomy is not a curative operation for this condition, and even may accelerate its malignant course, as occurred in the case presented.

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Case Reports

Carbon Dioxide Tolerance in Interstitial and Intravascular Spaces in Dogs

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The renewed interest in the adrenal, pancreas, and other retroperitoneal structures stands as a challenge to better diagnostic methods. The outline of the retroperitoneal space has been attempted with small quantities of air or oxygen.[1,2,5,9] However, air embolism following the presacral or flank injection of air or oxygen is being reported with increasing frequency.[3,4,6,8] Use of CO_2 as the agent for retroperitoneal insufflation would have the following advantages: (1) The high solubility of CO_2 would reduce the hazard of gas embolization; (2) CO_2 is free of allergic or idiosyncratic properties, and (3) CO_2 is readily available and is inexpensive. Stauffer, Durant, and Oppenheimer [7] have safely used CO_2 for delineation of the cardiac chambers in doses of 7.5 cc/kg. In the past six months we have been interested in the investigation of CO_2 as a medium for outlining the retroperitoneal, intraperitoneal, intravascular, intracardiac, cerebrospinal, intravesical, and retrothoracic spaces. The present communication undertakes to describe observations on (1) the volume of CO_2 which produces satisfactory contrast for roentgenologic study when deposited in the retroperitoneal space, (2) the rate of dissipation of the gas from the retroperitoneal space, (3) the tolerance of dogs for massive retroperitoneal injection of CO_2 in amounts 4 to 20 times that required for diagnostic studies, and (4) the maximum rate and total volume of CO_2 that can be tolerated by intravenous administration.

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From the Department of Surgery, Hahnemann Medical College and Hospital of Philadelphia.

Materials and Methods

A series of 20 mongrel dogs, weighing from 11 to 22 kg. was used. An 18-gauge needle was inserted in the midline posterior to the rectum so that the tip of the needle rested in the loose areolar tissue immediately anterior to the sacrum. The needle was aspirated to ensure an extravascular position. A cylinder of CO_2 gas with a flow meter was connected to the needle with rubber tubing. CO_2 was introduced into the retroperitoneal space at a rate of 1 to 3 liters per minute. X-rays were taken during the injection of CO_2, immediately after the introduction of the gas, and at frequent intervals thereafter. Between x-ray examinations fluoroscopy was used to follow the course of the dissipation of the gas.

Intravenous injection of the gas at a rate of 0.2 to 2 liters per minute was performed on 10 dogs in the anesthetized state.

Results

Evaluation of the adequacy of contrast in the retroperitoneal area in animals receiving 0.2 to 20 liters of CO_2 suggests that between 50 and 100 cc. per kilogram is optimal. Amounts in excess of 100 cc/kg. did not appear to improve the roentgenologic detail to a significant degree. Detail and clarity after less than 50 cc/kg. usually was unsatisfactory for diagnostic purposes (Figs. 1 and 2).

There was considerable variability in the rate of disappearance of the gas from the retroperitoneal space. As would be expected, CO_2 is absorbed much more rapidly than O_2 or air. However, satisfactory contrast

Fig. 1.—Scout film prior to retroperitoneal injection of CO_2.

Fig. 2.—Scout film following injection of 100 cc. per kilogram of CO_2.

is maintained for periods of 20 to 30 minutes.

Ten unanesthetized animals were subjected to massive retroperitoneal CO_2 insufflation (200 to 1200 cc/kg.) and the results observed (Table 1). All the animals survived; transient hyperpnea and tachypnea were noted in a few animals. Some of the animals gave evidence of mild discomfort, particularly during the early part of the injection, but none showed any indication of severe pain or agitation.

Intravenous administration of CO_2 was carried out in a large number of animals to determine the rates of administration and the total volumes which are compatible with survival. It soon became apparent that amounts of less than 20 cc/kg/min. were well tolerated for long periods. In Table 2 are recorded the results of a series of 10

TABLE 1.—*Retroperitoneal Carbon Dioxide Insufflation in Unanesthetized Dogs*

No.	Weight, Kg.	Rate, L/Min.	Volume CO_2, Liters	L/Kg.	Side-Effects
1	15	1.2	12	0.8	Transient depression
2	12	1.2	14	1.2	Slight agitation
3	19	1.5	4	0.2	None
4	11	1.5	7	0.6	None
5	20	1.5	12	0.6	None
6	18	1.5	17	0.9	Restlessness
7	21	1.5	20	0.95	Slight agitation
8	15	2.0	5	0.33	Transient tachypnea
9	22	2.5	8	0.4	Defecation
10	16	2.5	8	0.5	Restlessness

TABLE 2.—*Intravenous CO_2 Tolerance in Anesthetized Dogs*

No.	Weight, Kg.	Rate, Cc/Min.	Volume, Cc.	Cc/Kg.	Cc/Kg/Min.	Resu
1	9.9	400	1100	110	40	Recovery
2	15.0	400	1800	120	27	Recovery
3	12.0	400	2400	200	33	Recovery
4	10.0	400	2400	240	40	Recovery
5	16.0	400	4800	300	25	Recovery
6	15.0	400	2000	130	26	Recovery
7	15.0	400	4000	280	28	Recovery
8	20.0	1000	1000	50	50	Recovery
9	17.0	1000	1000	60	60	Recovery
10	19.0	2000	1500	80	106	Recovery

dogs which received from 25 to 106 cc. per kilogram per minute for brief periods of time, the duration being determined by the animal's tolerance. All of these injections were to the full tolerance of the animal, i. e., until one or more evidences of decompensation appeared, namely, bradycardia, cardiac arrest, respiratory depression, or apnea. It is apparent that the more rapid rates of injection (60 cc/kg/min. and up) are increasingly hazardous and that the total tolerance of CO_2 decreases as the rate of injection increases. It is notable that all the animals receiving CO_2 at less than 40 cc/kg/min. survived and that the total volume of CO_2 tolerated exceeded 100 cc/kg. in each case.

Summary

Carbon dioxide gas given retroperitoneally was tolerated by dogs in amounts of 200 to 1200 cc. per kilogram without significant untoward reactions.

X-ray studies after 50 to 100 cc/kg. showed satisfactory detail of the retroperitoneal structures.

Absorption of the gas, although marked by individual variability, was not sufficiently rapid to be hazardous or to preclude adequate time for diagnostic roentgenologic study.

Carbon dioxide given intravenously was well tolerated at rates which did not exceed 40 cc/kg/min. for injections of short duration. All of the animals studied survived intravenous injections of 100 cc/kg. or more when given at this rate.

The wide safe range of retroperitoneally administered CO_2, the rapid solubility of the gas, and the tolerance of intravenous CO_2 suggest that the danger of death from gas embolization in retroperitoneal CO_2 studies would be nil.

NOTE: Since the completion of this investigation, we have performed retroperitoneal CO_2 insufflation in 20 patients without untoward reactions and with satisfactory diagnostic results.

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Intestinal Obstruction in the Newborn Due to a Sigmoid Colon Valve

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Intestinal obstruction in the neonatal period secondary to the congenital anomalies of malrotation, peritoneal bands, atresias, stenoses, reduplications, and meconium ileus are well-recognized clinical entities which have been lucidly and precisely described and reported in the surgical literature and standard textbooks. In 1922 Davis and Poynter [1] were able to collect 392 cases of congenital occlusion of the intestine between the pylorus and the anus from the world literature. Since 1922 similar reports have been so numerous that additional case reports serve no function unless some unusual feature is present which has rarely been encountered. A careful review of the literature has revealed no recent description of intestinal obstruction of the newborn due to a rectosigmoid valve. However, in 1900 Ecoffet,[2] in a thesis on congenital intestinal occlusions, cited a case of intestinal obstruction in an 18-day-old child due to the presence of a valve in the transverse colon. Kuliga,[3] in 1903, in reviewing a large series of congenital atresias and stenoses of the gastrointestinal tract, was able to collect four cases of intestinal obstruction in the neonatal period due to membranous valves of the colon. In one of these cases the valve was at the rectosigmoid junction. In the other three cases the valves were, respectively, in the ascending colon, at the junction of ileum and cecum, and in five different locations in the colon. The following case report is presented because of the relative rarity of the lesion.

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Presented at a meeting of the New York Surgical Society, April 10, 1957.

From the Surgical and Laboratory Divisions and the Pediatric Service, the Montefiore Hospital.

Report of Case

A 60-hour-old white premature male infant was admitted to Montefiore Hospital on March 30, 1956, because of persistent vomiting since 12 hours of age. The infant was born on March 28 by breech extraction three weeks prior to the estimated date of confinement. The weight at birth was 4 lb. 15 oz. (2240 gm.). He cried and breathed spontaneously and showed no abnormalities other than an incomplete formation of the prepuce. Glucose water feedings were begun at 12 hours of age and resulted in bile-stained vomitus; a scant, dry meconium stool was passed. At 24 hours of age there was a slight abdominal distention. A flat plate of the abdomen at 36 hours showed gas-filled small and large intestinal loops. Bile-stained vomiting persisted, and the abdominal distention increased. Ten cubic centimeters of iodized oil U. S. P. (Lipiodol) was given by mouth and was followed with serial abdominal films. This material promptly passed through the stomach, duodenum, and jejunum and became arrested in the ileum, where it remained absolutely stationary over a period of eight hours (Fig. 1*A* and *B*). Because of increasing distention and clinical deterioration, with x-ray evidence of a block to the further progression of the iodized oil, a diagnosis of mechanical obstruction of the small bowel, possibly on the basis of a peritoneal band or stenosis of the ileum, was made. The patient was transferred to the Montefiore Hospital for surgical exploration.

Physical Examination.—Except for the abdominal distention, an incomplete prepuce, and unusually short digits of the hands with increased curving of the little fingers, the examination was unremarkable. Under combined local block with 0.5% procaine hydrochloride and oral administration of a whiskey-saturated sugar nipple, an exploratory laparotomy was carried out through a right-rectus-muscle-splitting incision. Generalized distention of the gastrointestinal tract, involving the stomach and small and large bowel, was noted, but no obstructing lesion, either extrinsic or

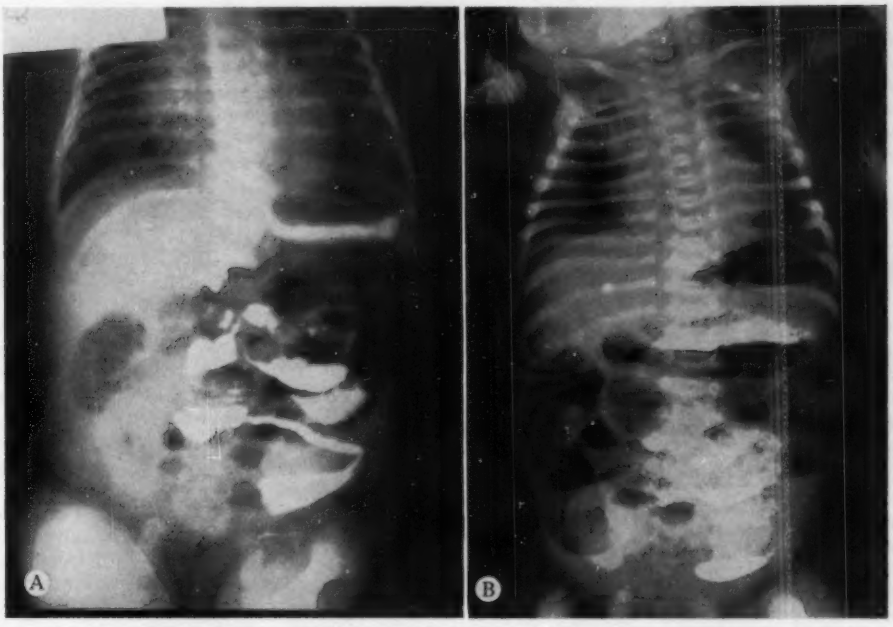
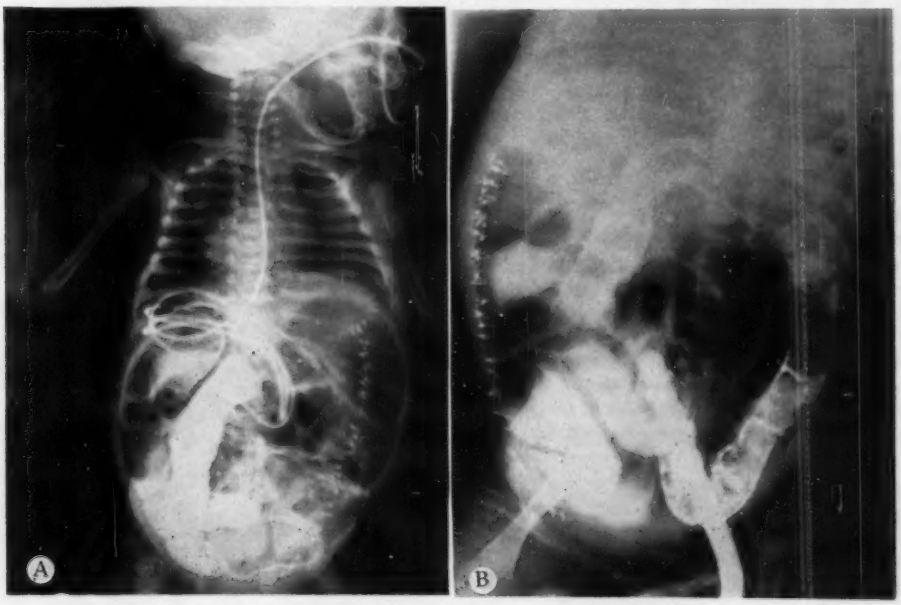


Fig. 1.—Roentgenograms of abdomen after oral administration of iodized oil U. S. P. (Lipiodol), (*A*) initially and (*B*) eight hours later. Little progression of the dye in the ileum is noted.

Fig. 2.—(*A*) Roentgenogram of abdomen on readmission, showing generalized ileus; (*B*) barium enema, revealing patency throughout colon.



intrinsic, was detected, nor was there evidence of a meconium ileus. During the exploration no peristaltic waves were seen anywhere in the gastrointestinal tract. Postoperatively, the infant was maintained on intravenous and clysis feedings for one day and then started on oral feedings. These were gradually increased and retained in increasing quantities. Normal-appearing stools were passed; the child remained afebrile, and the wound healed per primam. The patient was discharged from the hospital on the 11th postoperative day, on an adequate formula, passing normal stools daily.

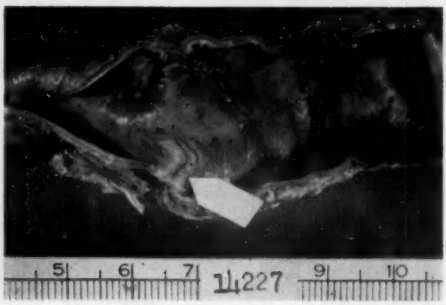
At home, the child continued to do well for a few days, after which vomiting reappeared. This was insignificant at first but increased daily and became associated with gradually increasing abdominal distention. Two days before readmission, on April 24, the child began vomiting every feeding and stopped having stools completely.

Physical examination on readmission revealed moderate dehydration, with abdominal distention and occasional peristaltic rushes. A flat plate of the abdomen revealed distended loops of small and large bowel with fluid levels, which was interpreted as evidence of a generalized ileus (Fig. 2*A*). Nasogastric suction was instituted, with enemas from below to break up a possible fecal impaction, with only fair improvement in the distention. A barium enema examination (Fig. 2*B*) on April 25 showed normal filling of the colon. Repeated Harris flushes from below, castor oil by mouth, and neostigmine subcutaneously were temporarily successful in decreasing the abdominal distention. The improvement, however, rapidly gave way to clinical deterioration with increasing distention, daily temperature spikes, and hyperactive peristaltic waves seen visibly through the anterior abdominal wall. Reexploration was decided upon with a preoperative diagnosis of mechanical intestinal obstruction of unknown etiology, with aganglionosis of a segment of bowel as a good possibility. At the second exploration, on April 29, numerous adhesions between segments of small and large bowel were lysed. The generalized distention previously noted was again present, with no specific single point of obstruction. Since the ileocecal region felt thickened and there was some resistance to the flow of material milked from the terminal ileum into the cecum, an anastomosis, side to side, was created between the terminal ileum and the ascending colon. Postoperatively, the child did poorly, with persistent vomiting, bowel distention, and fecal drainage from the operative wound. Terminally, the patient developed twitching, stertorous breathing, generalized edema, and a bleeding tendency, and died on May 5, at the age of 38 days. The clinical impression was mechanical obstruction of the small and large bowel, possibly on the basis of aganglionosis.

At necropsy, the positive findings were limited to the gastrointestinal tract. The esophagus was normal, and the stomach was slightly distended. The small bowel was patent throughout and slightly dilated. The anastomosis in the ileocecal region was patent, as was the ileocecal valve. There was a dehiscence of the suture line of the anastomosis for a distance of 0.5 cm., from which area fecal contents were noted to exude into the peritoneal cavity. The colon contained yellow-brown fecal material and was patent throughout. The colon itself was dilated, and the walls were thickened. The mucosa appeared thinned, and there were no polyps or diverticula. Approximately 7 cm. above the anal orifice the colon was observed to narrow down to its normal diameter. When the bowel was opened at this level, an indentation of the wall and mucosa was observed, which measured approximately 3-4 mm. in length and pointed downward toward the rectum (Fig. 3). This area was firm in consistency and was seen partially to occlude the lumen of the colon. This area was approximately 3 cm. above the peritoneal reflection. The rectum was normal except for a small ulceration about 4 cm. above the anal orifice.

Microscopic examination of the stomach and esophagus was negative. Sections taken through the jejunum and ileum revealed a normal distribution of ganglion cells between the circular and the longitudinal muscle bundles (Fig. 4*A*). Microscopic examination of the descending colon disclosed that the mucosa and muscularis were somewhat flattened. Nerve bundles and ganglion cells were present between the circular muscle layer and the taenia coli (Fig. 4*B*). Sections taken through the valve-like projection in the sigmoid colon showed that this valve was composed of an infolding of the muscular layer, over which lay normal colonic mucosa. The circular layer of muscle appeared in one portion of this valve and

Fig. 3.—Rectosigmoid area at necropsy, with dilated colon proximally and rectum of normal caliber distal to the valve.



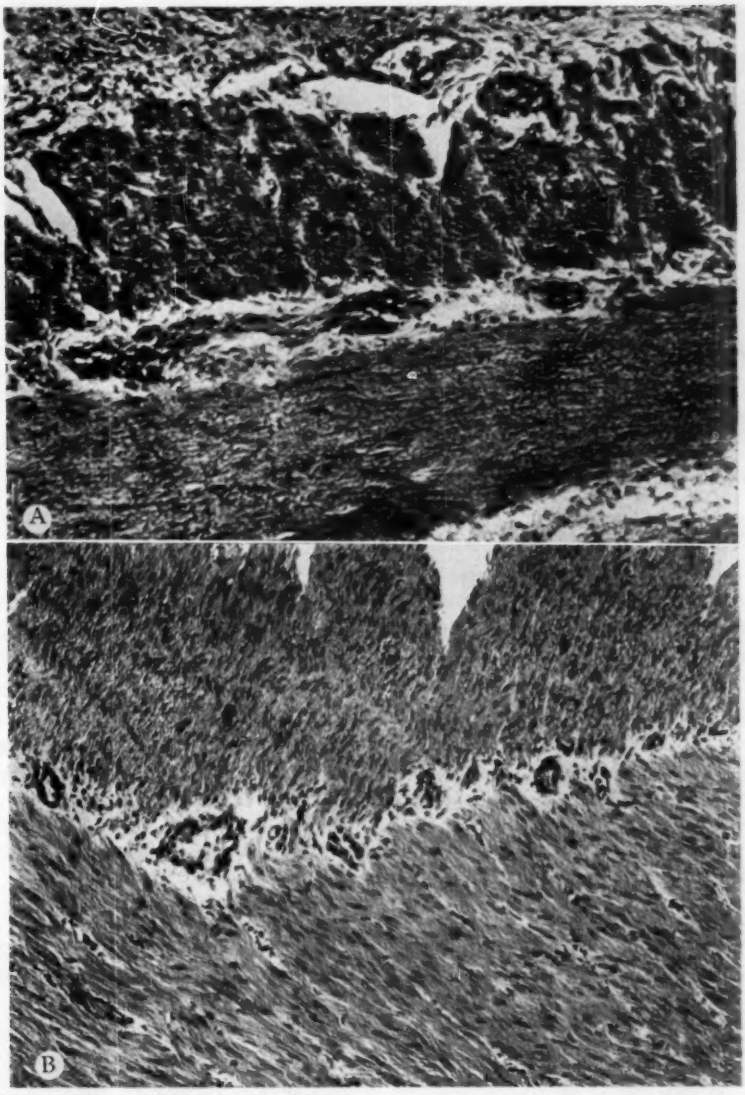


Fig. 4.—Microscopic sections of (*A*) jejunum and (*B*) descending colon, with ganglion cells in normal distribution. Hematoxylin-eosin stain reduced to 71% of mag. × 150.

was thickened in contrast to the surrounding regions (Fig. 5). The submucosal connective tissue did not appear to be increased or thickened. An acute peritonitis was present, characterized by necrosis, hemorrhage, and an outpouring of inflammatory cells, fibroblasts, and fibrin.

Comment

A series of events takes place between the 5th and the 10th week of fetal life which determines whether the gastrointestinal tract will have normal patency or whether stenosis or atresia will result. Prior to the fifth week the gastrointestinal tract has a well-defined lumen lined with epithelium. Following this, the intestine passes through a solid stage as the epithelium rapidly proliferates, obliterating the lumen. Vacuoles then appear within this epithelial proliferation, re-

Fig. 5.—Microscopic section of valve, composed of an infolding of the muscular layer, covered with normal colonic mucosa. Hematoxylin-eosin stain; reduced to 61% of mag. × 20.

establishing the lumen. If the hollow tube re-forms but fails to attain a normal diameter, a stenosis results. If one of the septa persists, or if the intestine becomes pinched off during the solid stage, atresia results. Thus, intestinal atresia has been described in one of two forms: (*a*) There may be an internal diaphragm or veil which completely blocks the lumen, or (*b*) the intestine may end as a blind sac and there is a discontinuity of the bowel. We believe the present case report represents a third form of atresia, in which an incomplete diaphragm persists as a valve-like projection, producing varying degrees of incomplete obstruction. A review of the literature has failed to discover a description of a similar lesion as a cause of intestinal obstruction.

It is interesting to note the similarity between the valve-like lesion in this case and the normally occurring valves of Houston, located in the rectum. Normally, above the valves of Houston, at the rectosigmoid junction as the sigmoid and rectum join at an angle, a fold of mucosa projects into the lumen. This was described by O'Beirne [4] as a valve, and to it he attributed a sphincteric action. The dissections of Burden and Martin [5] in this area have failed to reveal any increase in circular muscle fibers sufficient to suggest an anatomic sphincter. The lesion in our case report was approximately 7 cm. above the anal orifice and 3 cm. above the peritoneal reflection.

In retrospect, a simple transverse colostomy would have been very effective. The failure of the barium enema to reveal this lesion and the inability to palpate the valve during the two explorations resulted in a failure to make the diagnosis ante mortem. The presence of generalized distention of both small and large bowel should have indicated that a low-lying lesion was present. Under such circumstances a "blind" transverse colostomy may have been justified.

Summary

A case of intestinal obstruction in the newborn due to a rectosigmoid valve is presented.

A review of the literature reveals that this is a rare lesion.

A "blind" transverse colostomy is suggested as a method of management when exploration reveals generalized large- and small-bowel distention with no demonstrable anatomic cause.

Montefiore Hospital (67) (Dr. Hurwitt).

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Incomplete Rupture of the Colon Following Hydrogen Peroxide Enema

LOUIS G. LUDINGTON, M.D.; SHERMAN W. HARTMAN, M.D.; JAMES E. KEPLINGER, M.D., and FRANK S. WILLIAMS, M.D., Los Angeles

An unusual case of incomplete rupture of the sigmoid and transverse colon following a hydrogen peroxide enema is presented. Examination of the medical literature failed to reveal a similar case, though there have no doubt been others. This case is recorded to show the danger of injecting hydrogen peroxide solutions into closed body cavities and as an interesting and unusual cause of incomplete rupture of the colon.

Report of Case

A 62-year-old white man with a 15-year history of peptic ulcer was admitted to the Wadsworth Hospital on May 7, 1957, because of weakness, syncope, and hematemesis six days prior to admission. On admission, his hemoglobin was 10.7 gm. per 100 cc., having dropped from 12.6 gm. a few days earlier. A review of his past history revealed a previous bleeding episode 10 years earlier. He had had known hypertension three years and symptoms of angina pectoris for the same length of time. Two months prior to admission he suffered a cardiovascular accident, which left him with right spastic hemiplegia and some impairment of memory.

On appropriate medical treatment the duodenal ulcer was brought under control and the hemoglobin was restored to 12.6 gm. without transfusion. During the first week of his hospital stay, the patient became greatly disturbed about his bowels. He had had no movements since admission, and several tap-water enemas had produced no results. Before noon on May 13, the ward physician ordered and supervised a hydrogen peroxide enema. This consisted of 1 cup (4 oz. [125 cc.]) of hydrogen peroxide in a liter of warm water. Because the patient had previously demonstrated inability to retain the enema solution, owing to poor anal sphincter tone, this enema solution was administerd through a Foley catheter, the balloon of which had been inflated and impinged against the anal outlet. The solution was retained between 10 and 15 minutes by clamping the catheter. During this time the patient complained of some discomfort and began to perspire freely. On removal of the catheter, the evacuation was described as good, with much hard and soft stool.

During the afternoon following the enema the patient complained of increasing abdominal pain and began to run a mild degree of fever. The ward doctor noticed that there was rebound tenderness present and ordered a blood count, abdominal x-ray series, and a surgical consultation. When the patient was seen about 5:30 p. m., there was definite generalized rebound tenderness but only mild rigidity. The maximum tenderness was in the left lower quadrant of the abdomen. Sensation of the right side of the abdomen was decreased, due to the hemiplegia. The white blood cell count was 14,200, with a shift to the left, and the temperature was 103 F. The white blood cell count several days earlier had been 7000. Abdominal x-rays failed to reveal any free air, but the colon was distended with air. Laparotomy was advised and the patient taken to surgery that night. It was expected that a ruptured diverticulum of the sigmoid colon would be found.

On opening the abdomen, a minimal amount of blood was found in the pelvis, and a 2 in. rent in the seromuscular layer of the sigmoid colon along its antimesenteric border. The mucosa was bulging through this rent, but was intact. Further examination revealed a 5 in. laceration of the seromuscular layer of the right transverse colon, again along the antimesenteric border. Through this bulged the intact mucosa, but at its center was a circular area of gangrenous discoloration 3.5 to 4 cm. in diameter. A thin, grayish white exudate covered this. The entire colon was empty of fecal material. The involved loop of transverse colon was exteriorized through a counterincision in the right upper abdomen and the tear in the sigmoid seromuscular layer repaired with interrupted silk sutures. The patient has had an uneventful postoperative course.

Submitted for publication Sept. 9, 1957.

From the Wadsworth General Medical and Surgical Hospital, Veterans' Administration Center.

Comment

Hydrogen peroxide has long been a popular household antiseptic and disinfectant. It is the richest oxygen compound known, and the commercially prepared solution is 3% in water and is recognized in the United States Pharmacopeia. This solution yields about 10% oxygen. It is fairly stable in pure solution with appropriate preserver, but in the presence of sunlight, heat, or certain inorganic or organic catalyzers, it splits off nascent oxygen rapidly. Body tissues contain the enzyme catalase, which rapidly catalyzes the breakdown of hydrogen peroxide. Blood, pus, and autolyzing tissues are particularly rich in this enzyme. This release of oxygen is weakly germicidal, but the action is brief. However, the effervescence of the oxygen affords a mechanical means of removing tissue debris from inaccessible regions.[5,7,9,10]

Medicinally, hydrogen peroxide has been used most extensively for cleaning fetid wounds, ulcers, abscess cavities, fistulous tracts, etc. It has also been used as a mouth wash in Vincent's angina, as a vaginal irrigation for Trichomonas vaginalis, to destroy bacteria in drinking water and milk, and as an antidote for cyanide and phosphorus poisoning, oxidizing them into inert bodies KCNO and P_2O_5 respectively. It has been used with barium medium to demonstrate ulcers and tumors of the esophagus and stomach roentgenologically, rapid effervescence occurring when the mixture contacts blood, pus, or ulcerated sites, and this effervescence can be noted at fluoroscopy. Paavo Klami first used this "pathology sensitive barium" in 1953. Gianturco and Miller[4] advised giving 2 oz. (60 gm.) of barium and following this with 2 oz. (60 cc.) of 3% hydrogen peroxide when malignancy of the cardiac end of the stomach or ulcers of the lower esophagus were suspected. They reported no complications other than nausea and vomiting. In 1954 Olim and Ciuti[8] described the effective use of hydrogen peroxide in relieving meconium ileus. They reported two cases in infants with cystic fibrosis of the pancreas. A 1:3 dilution of hydrogen peroxide U. S. P. was administered in 10 cc. doses distally and proximally through a ileotomy wound in the first case, and per rectum, as an enema, in the second case. The nascent oxygen liquefied the mucosal mucous secretions, thus relieving surface tension and allowing the meconium to pass.

Hydrogen peroxide enemas have been reported to be of benefit in relieving barium impaction of the rectum. Govoni, Brailsford, and Macklow[6] described use of hydrogen peroxide enemas for eliminating all gas from the colon prior to roentgen studies of abdominal viscera. They used 10 cc. of hydrogen peroxide per liter of water, introduced slowly with the patient lying in each of the four positions. In over 300 cases so treated they had no serious complications. They were careful to evacuate the solution at the first sign or symptom of vague abdominal discomfort; otherwise diffuse atony of the bowel resulted.

Probably the incomplete rupture of the colon in the case presented would not have occurred if the rectum had not been blocked off. The right hemiplegia probably diminished symptoms of distention, though the patient did complain of discomfort, and this should have been a warning to the physician.

Burt[2] found that under experimental conditions the human colon bursts with only about 4 lb. pressure, and that the serous and muscular coats tear first, at about 3½ lb. pressure. Rupture of the intestine probably depends on the suddenness of the pressure, as well as the amount. Duval noted tremendous dilatation of the colon in a mentally deranged patient who inflated his colon by means of a bicycle hand pump. The bowel mucosa can adapt itself more rapidly than the outer, seromuscular coat. In reported cases of pneumatic rupture of the bowel from compressed-air pumps, the rents occur along one of the muscle bands on the antimesenteric border, with the underlying mucosa intact in many cases. Brown and

Dwinelle[1] described it aptly: "The inner mucosal tube balloons out through the split outer muscular tube like the 'blow-out' of a pneumatic tube." If rupture of the mucosa does occur, it will be smaller than the outer tear, and may retract beneath the edge of the outer tear. The tears in the outer coat, if multiple, increase in size as they are traced proximally along the colon. If complete rupture occurs, it will usually be at only one or two sites in the multiple tears of the outer bowel.[8]

Summary

Any unusual case of incomplete rupture of the sigmoid and transverse colon following a hydrogen peroxide enema is presented. The enema consisted of 4 oz. (125 cc.) of hydrogen peroxide in a liter of water, administered through a Foley catheter and retained for 10 to 15 minutes before evacuation. Two seromuscular tears along the mesenteric borders of the sigmoid and transverse colon resulted, with the intact mucosa bulging and gangrenous in one area of the transverse colon.

Hydrogen peroxide releases nascent oxygen rapidly when in contact with organic catalase, an enzyme present in body cells and in active concentration in autolyzing body tissues, blood, and pus. Probably the putrefactive products of the colon contain large amounts of this enzyme. This distention injury resulting from rapid release of large amounts of nascent oxygen is similar to the compressed-air injuries of the colon reported in the literature. Injecting hydrogen peroxide into closed body cavities can be dangerous, as this case demonstrates. If such enemas are used for relieving difficult fecal impactions, such as, for example, barium impactions, then the rectum should not be blocked, and the solution must be allowed to escape at the first signs and symptoms of any abdominal discomfort.

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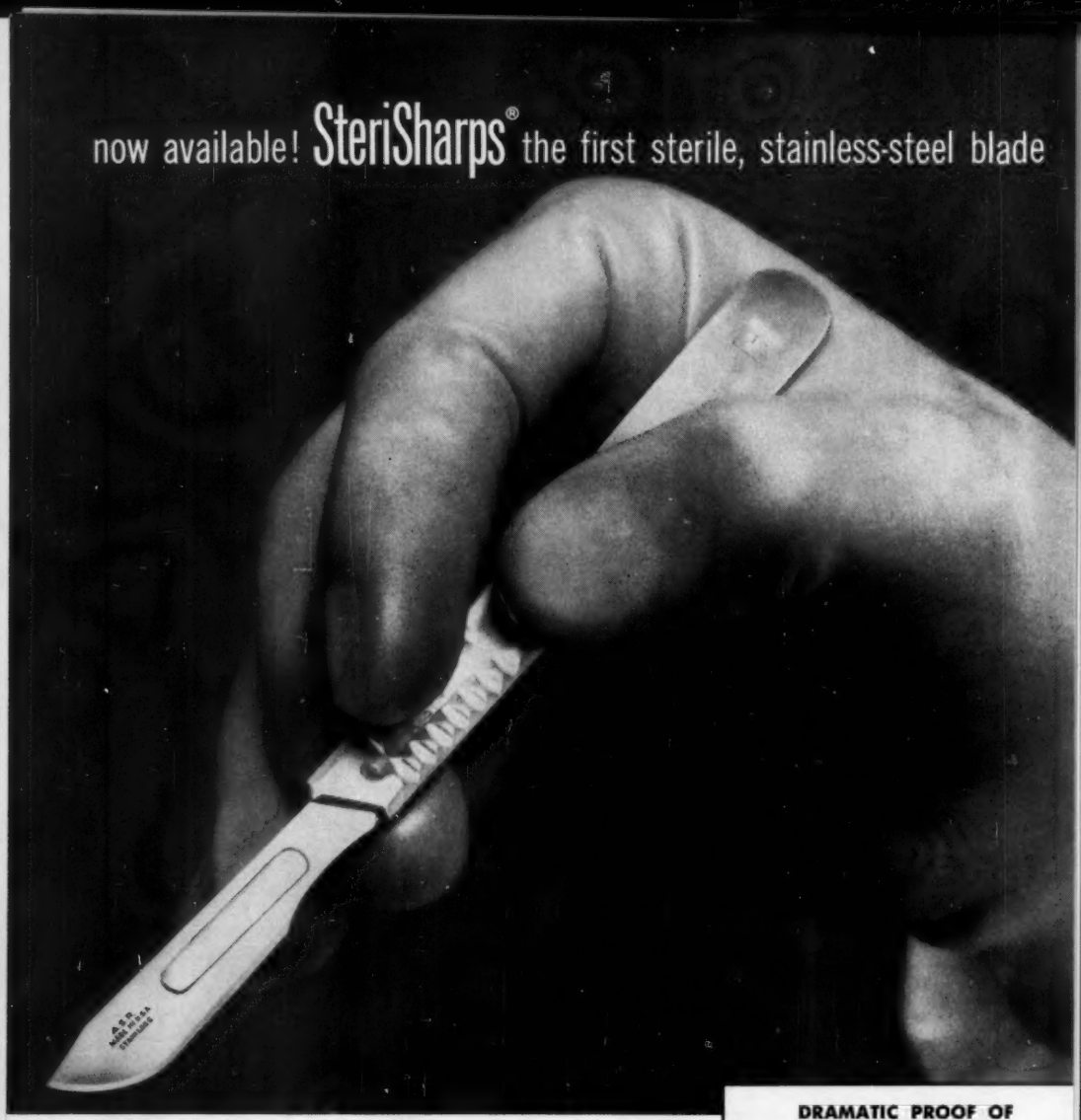

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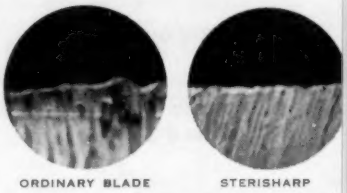

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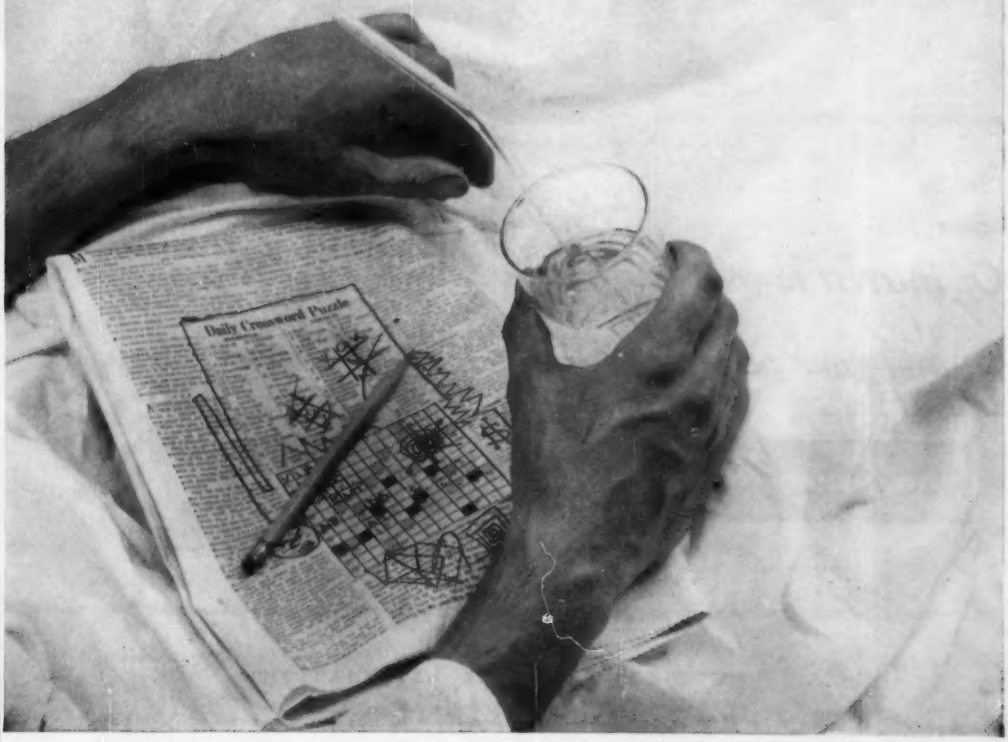

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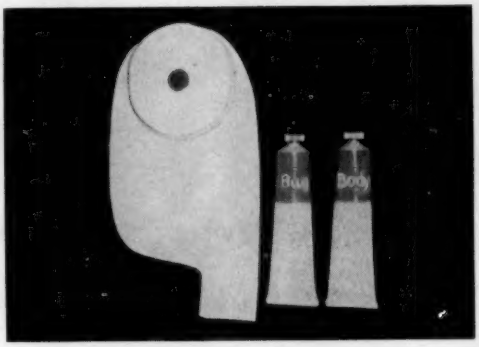

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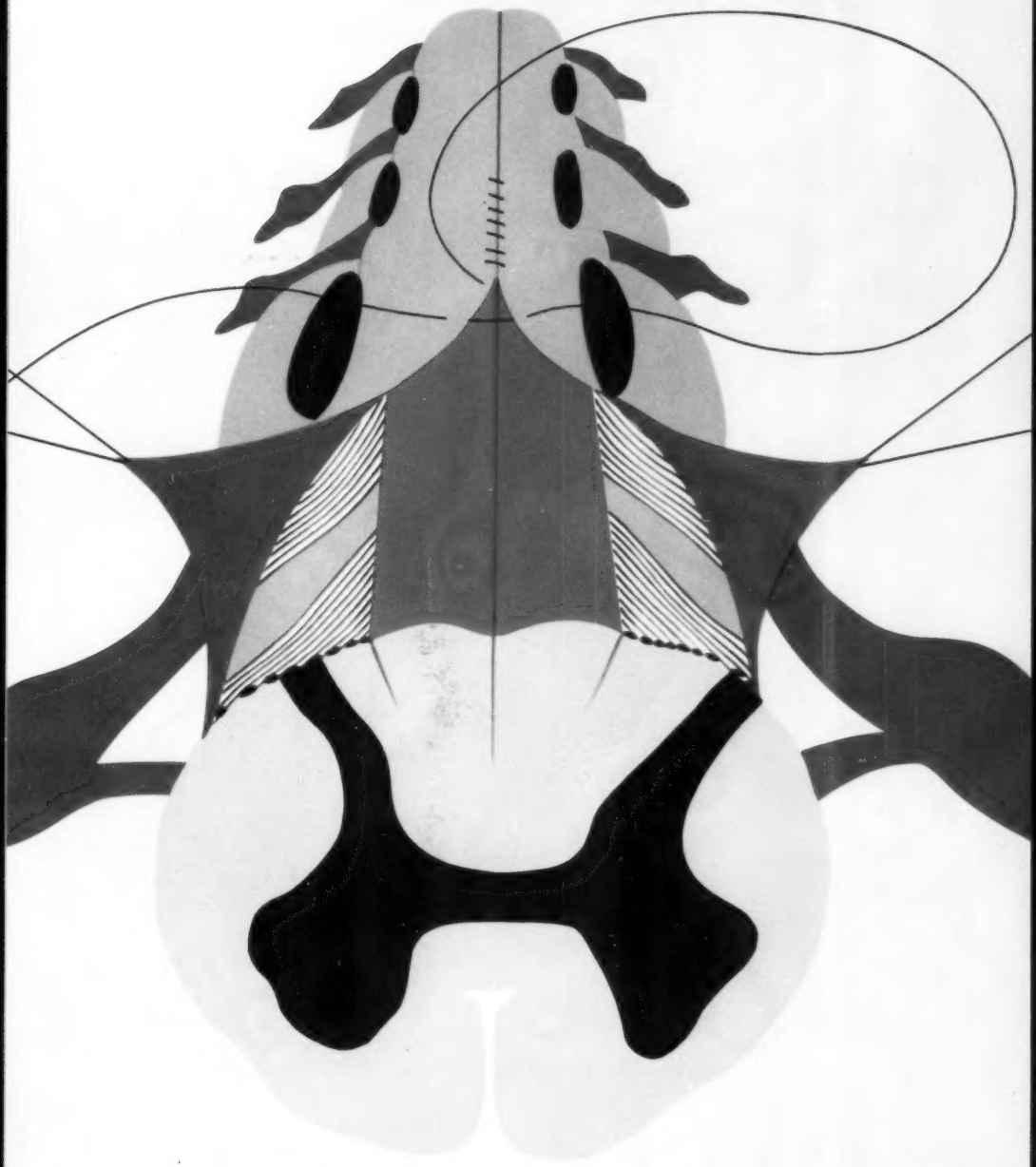

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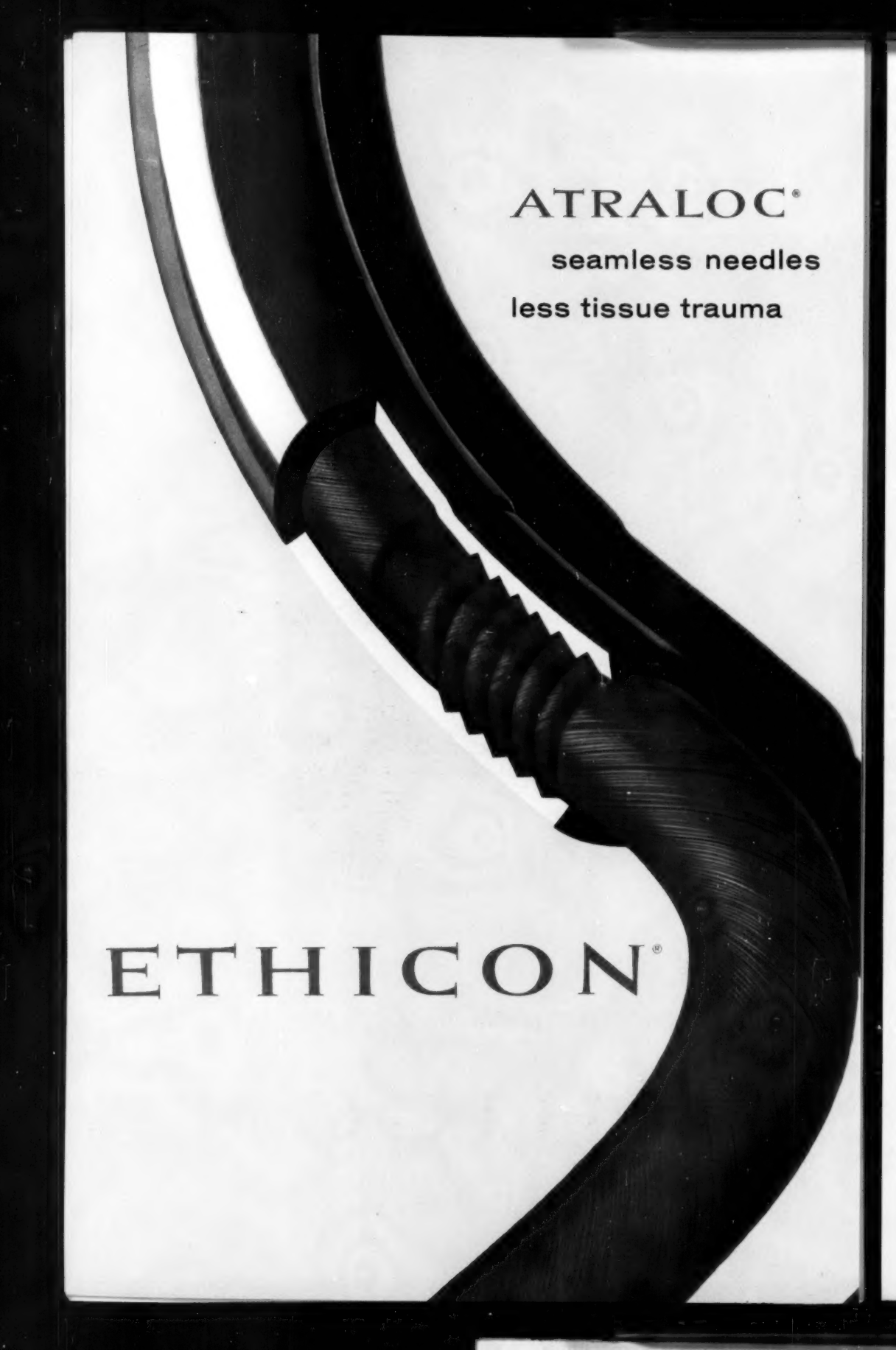
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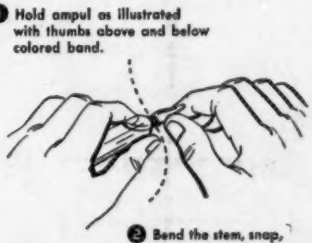

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